2006 Nebraska Groundwater Quality Monitoring Report

Prepared Pursuant
to Neb. Rev. Stat. §46-1304
(LB329 – 2001)

Nebraska Department of Environmental Quality
Water Quality Assessment Section
Groundwater Unit

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Photo on front cover:

Boiling Springs, Garden County. (Sheila Oborny, Blue Creek Ranch)

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INTRODUCTION

The 2001 Nebraska Legislature passed LB329 (Neb. Rev. Stat. §46-1304) which, in part, directed the Nebraska Department of Environmental Quality (NDEQ) to report on groundwater quality monitoring in Nebraska. Reports have been issued since December 2001. The text of the statute applicable to this report follows:

> "The Department of Environmental Quality shall prepare a report outlining the extent of ground water quality monitoring conducted by natural resources districts during the preceding calendar year. The department shall analyze the data collected for the purpose of determining whether or not ground water quality is degrading or improving and shall present the results to the Natural Resources Committee of the Legislature beginning December 1, 2001, and each year thereafter. The districts shall submit in a timely manner all ground water quality monitoring data collected to the department or its designee. The department shall use the data submitted by the districts in conjunction with all other readily available and compatible data for the purpose of the annual ground water quality trend analysis."

The section following the statute quoted above (§ 46-1305), requires the State's Natural Resources Districts to submit an annual report to the legislature with information on their water quality programs, including financial data. This report has been prepared by the Nebraska Association of Resources Districts and is being issued concurrently with this groundwater quality report.

GROUNDWATER IN NEBRASKA

Groundwater can be defined as water that occurs in the open spaces below the surface of the earth (Figure 1). In Nebraska (as in many places worldwide), useable groundwater occurs in voids or pore spaces in various layers of geologic material such as sand, gravel, silt, sandstone, and limestone. These layers are referred to as aquifers where such geologic units yield sufficient water for human use. In parts of the state, groundwater may be encountered just a few feet below the surface, while in other areas, it may be a few hundred feet underground. This underground water "surface" is usually referred to as the water table, while water which soaks downward through overlying rocks and sediment to the water table is called recharge (Figure 1). The amount of water that can be obtained from a given aquifer may range from a few gallons per minute (which is just enough to supply a typical household) to many hundreds or even thousands of gallons per minute (which is the yield of large irrigation, industrial, or public water supply wells).

Groundwater Velocity

In general, groundwater flows very slowly, especially when compared to the flow of water in streams and rivers. Many factors determine the speed of groundwater and most of these factors cannot be measured or observed directly. The most important geologic characteristics that impact groundwater velocity are as follows:

- The sediments in the saturated zone of the aquifer – for example, groundwater generally flows faster through gravel sediments than clay sediments.
- The 'sorting' of the sediments. Groundwater in aquifers with a mix of clay, sand, and gravel (poor sorting) generally does not flow as fast as in aquifers that are composed of just one sediment, such as gravel (good sorting).
- The 'gradient' of the water table. Groundwater flows from higher elevations toward lower elevations under the force of gravity. In areas of high relief, groundwater flows faster. A typical groundwater gradient in Nebraska is 10 feet of drop over a mile (0.002 ft/ft).
- Well pumping influences. In areas of the State with numerous high capacity wells (mainly irrigation wells), groundwater velocity and direction can be changed seasonally as water is pulled toward these wells.

Ultimately, groundwater scientists have determined that groundwater in Nebraska can flow as fast as one to two feet per day in areas like the Platte River valley and as slow as one to two inches per year in areas like the Pine Ridge in northwest Nebraska or the glacially deposited sediments in southeast Nebraska.

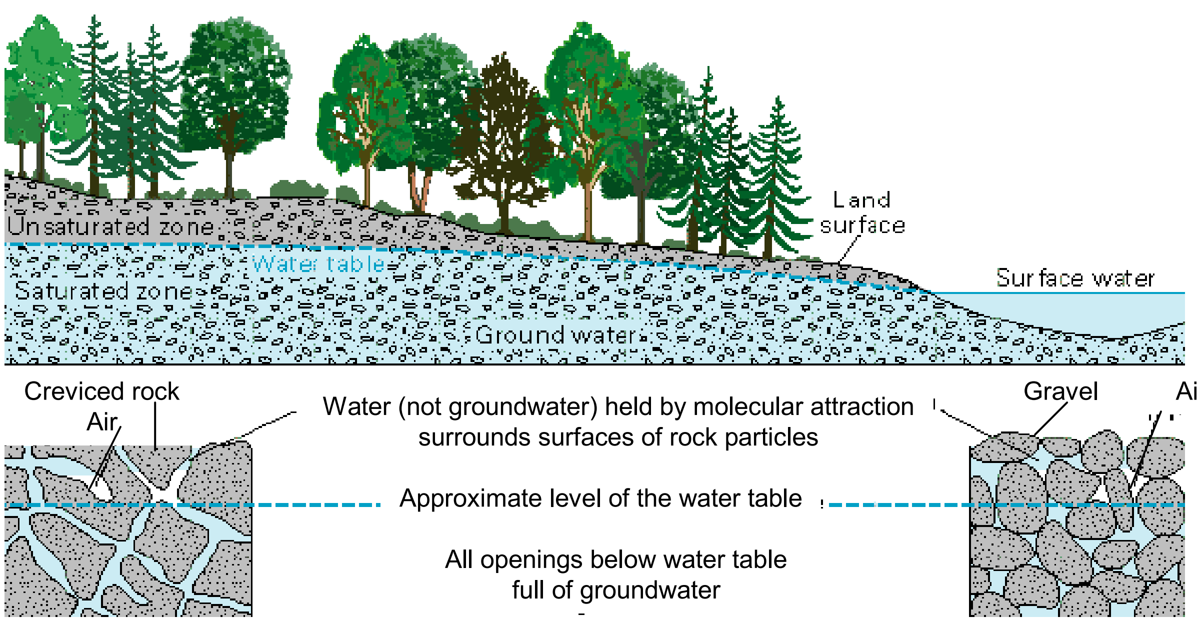


Figure 1. Basic groundwater features and terms.

Depth to Groundwater

The depth to groundwater plays a very important role in Nebraska's valuable water resource. Obviously, a shallow well is cheaper to drill, construct, and pump. Conversely, shallow groundwater is more at-risk from impacts from human activities. Surface spills, application of agricultural chemicals, effluent from septic tank leach fields, and other sources of contamination will impact shallow groundwater more quickly than groundwater found at depth. The map in Figure 2 shows the great variation of depth to water across the State.

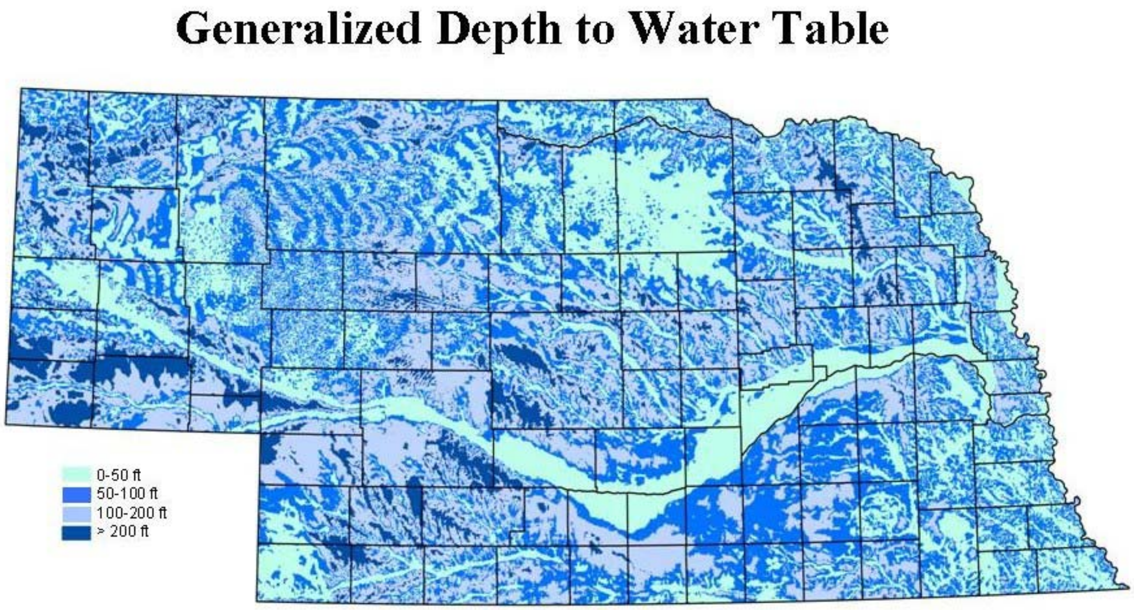


Figure 2. Generalized Depth to Groundwater (University of Nebraska, Conservation and Survey Division, 1998)

Importance of Groundwater

Nebraska is one of the most groundwater-rich places in the entire world. Nearly 85% of the state's residents use groundwater as their source of drinking water. If the public water supply for the City of Omaha (which gets about half of its water supply from the Missouri River) isn't counted, this rises to nearly 100%. Essentially all of the rural residents of the state use groundwater for their domestic supply. Not only does Nebraska depend on groundwater for its drinking water supply, the state's agricultural industry utilizes vast amounts of groundwater to irrigate crops. Most of Nebraska experiences variable amounts of precipitation throughout the year, so irrigation is used, where possible, to ensure adequate amounts of moisture for raising such crops as corn, soybeans, alfalfa, and edible beans. As of October 2006, the Nebraska Department of Natural Resources (NDNR) listed over 90,000 active irrigation wells and nearly 20,000 domestic wells registered in the state. The map in Figure 3 shows the density of irrigation wells in Nebraska as of August 2005. Domestic wells were not registered with the state prior to September 1993, therefore thousands of domestic wells exist that are not registered with the NDNR.

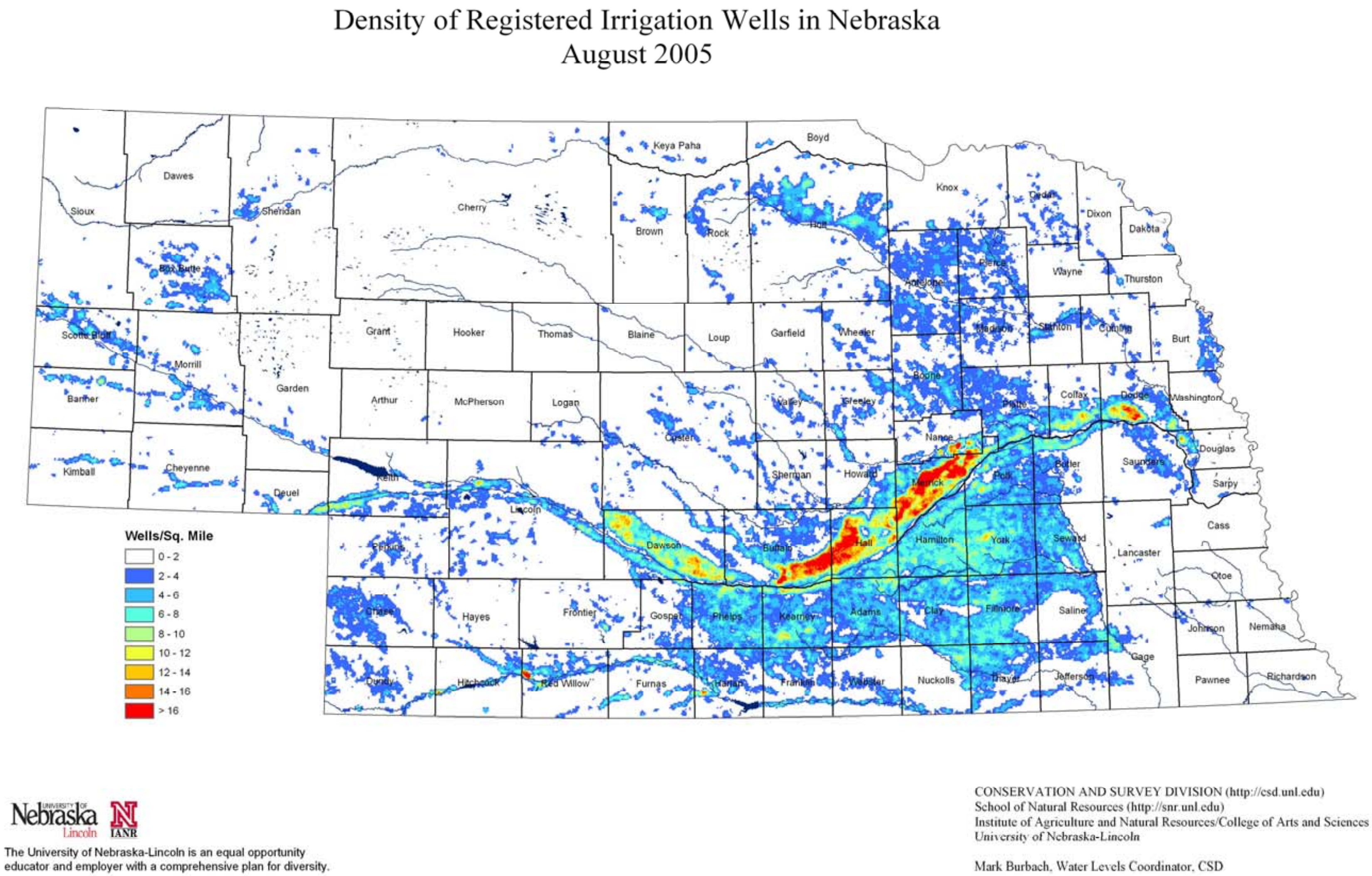


Figure 3. Density of Registered Irrigation Wells in Nebraska, August 2005 (University of Nebraska, Conservation and Survey Division, 2005)

Groundwater Monitoring

The above information shows clearly that groundwater is vital to the well-being of all Nebraskans. Fortunately, our state has a long tradition of progressive action in monitoring, managing, and protecting this most precious resource. Several agencies perform monitoring of groundwater for a variety of purposes.

Those entities include:

- Natural Resources Districts (23)
- Nebraska Department of Agriculture
- Nebraska Department of Environmental Quality
- Nebraska Health & Human Services
- University of Nebraska-Lincoln
- United States Geological Survey

Groundwater monitoring performed by these organizations meets a variety of needs, and therefore is not always directly comparable. For instance, the state's 23 Natural Resources Districts (NRDs) perform groundwater monitoring primarily to address contaminants over which they have some jurisdiction; mainly nitrates and agricultural chemicals. In contrast, the state's nearly 1300 public water suppliers monitor groundwater for a large number of possible pollutants. These include basic field parameters, agricultural compounds, and industrial chemicals. Not only are these samples analyzed for many different parameters, the methods used for sampling and analysis vary widely as well.

Partly in response to this situation, the Nebraska Departments of Agriculture (NDA) and Environmental Quality and the University of Nebraska - Lincoln (UNL) began a project in 1996 to develop a centralized data repository for groundwater quality information that would allow comparison of data obtained at different times and for different purposes. The result of this project is the Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater (referred to as the Database in this publication). The Database brings together groundwater data from many different sources and provides public access to this data.

The Database serves two primary functions. First, it provides the results of groundwater monitoring for agricultural compounds in Nebraska as performed by a variety of entities. At present, agricultural contaminants (mainly nitrate and pesticides) are the focus of the Database because of their widespread use, and also because historical data suggests that these compounds pose the greatest threat to the quality of groundwater across Nebraska. Second, the Database provides an indicator of the methodologies that were used in sampling and analysis for each of the results. UNL staff examine the methods used for sampling and analysis to assign a quality "flag" consisting of a number from 1 to 5 to each of the sample results. The flag depends upon the amount and type of quality assurance/quality control (QA/QC) that was implemented in obtaining each of the results. The higher the "flag" number, the better the QA/QC, and the higher the confidence in that particular result.

During the past several years, UNL staff have worked vigorously to establish contact with all the entities performing groundwater monitoring of agricultural chemicals (namely nitrates and pesticides) in Nebraska. Groundwater data is submitted to UNL by these entities each year, where it is assigned a quality "flag" and entered into the Database. The updated information is then forwarded to the Nebraska Department of Natural Resources (NDNR), which places it on its website (http://www.dnr.ne.gov/ or http://dnrdata.dnr.ne.gov/clearinghouse/). The entire Database can be accessed at NDNR's website, where the database may be searched or 'queried' for numerous subsets of data, such as results by county, type of well, Natural Resources District, etc.

GROUNDWATER QUALITY

Groundwater quality data presented in the remainder of this report reflect the data present in the Database as of October 1, 2006. The dates for these data range from mid-1974 to mid-2005. Some groundwater results from some of the agencies working in Nebraska have not to date been entered into the Database, but NDEQ is confident that the numbers presented represent the majority of sample results available.

Table 1 shows the total number of **groundwater analyses** reported by **each agency** producing groundwater quality data for Nebraska. In most cases in this report, the number of analyses for different parameters will be used to express sampling activity. It is important to keep in mind that an individual groundwater sample may in fact be analyzed for more than one parameter, just as an individual well may be sampled more than once. Therefore, the number of analyses exceeds the number of actual wells sampled.

Table 1 also shows that two NRDs have not contributed groundwater quality data to the Database. These NRDs' data are being collected by and submitted to the Database by the US Geological Survey, as part of cooperative agreements.

Agency	Total # of Analyses
Central Platte NRD	3,502
Lewis & Clark NRD	1,933
Little Blue NRD	2,322
Lower Big Blue NRD	4,257
Lower Elkhorn NRD	5,264
Lower Loup NRD	6,083
Lower Niobrara NRD	2,072
Lower Platte North NRD	4,637
Lower Platte South NRD	41,018
Lower Republican NRD	1,801
Middle Niobrara NRD	649
Middle Republican NRD	0
Nebraska Dept. of Agriculture	2,709
Nebraska Dept. of Environmental Quality	6,001
Nebraska Health & Human Services/CDC	45,236
Nemaha NRD	314
North Platte NRD	7,289
Papio-Missouri River NRD	42
South Platte NRD	3,198
Tri-Basin NRD	4,720
Twin Platte NRD	531
University of Nebraska - Lincoln	166,685
Upper Big Blue NRD	11,290
Upper Elkhorn NRD	6,710
Upper Loup NRD	37
Upper Niobrara-White NRD	2,576
Upper Republican NRD	0
U.S. Geological Survey	25,417
TOTAL	**356,293**

Table 1. Total number of analyses for groundwater in Nebraska provided to the Database by various agencies. (Source: Quality-Assessed Agrichemical Database for Nebraska Groundwater, 2006)

Types of Wells Sampled

The data summarized in Table 1 represent the quantity of water samples analyzed from a variety of well types. Historically, most wells that have been sampled are irrigation or domestic supply wells. Irrigation and domestic wells are constructed to yield adequate supplies of water, not to provide water quality samples. However, in recent years, monitoring agencies have been installing increasing numbers of dedicated groundwater monitoring wells designed and located specifically to produce samples. By utilizing such varied sources, groundwater data from a wide range of geologic conditions can be obtained. Table 2 shows the number of analyses from the Database for each type of well.

Well Type	Number of Analyses
Irrigation	74,523
Domestic	56,887
Public Water Supply	12,707
Commercial/Industrial	1,654
Monitoring	208,876
Livestock	1,641
Injection	3
"Other"	2
Total	**356,293**

Table 2. Total number of groundwater analyses by well type. (Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater, 2006)

Monitoring Parameters

As already mentioned, numerous entities across Nebraska have been monitoring groundwater quality for many years, for a wide variety of possible contaminants. However, much of this monitoring has been for area-specific (part of an NRD), or at most, regional purposes (entire NRDs), and it has been difficult to assess data on a statewide basis for more than a short period of time. Creation of the Agrichemical Database has provided an important tool for such analysis. Table 3 lists the compounds for which groundwater has been sampled and analyzed since 1974. Table 4 lists the compounds from Table 3 which have exceeded the ***Reporting Limit** (RL) and a comparison of the number of analyses performed for each compound and the number of times the RL was exceeded. This comparison gives an indication of which compounds are more prevalent than others in Nebraska's groundwater. For example, of the 74,525 samples analyzed for nitrate-nitrogen, 70,023 were above the RL as opposed to the 4,166 samples analyzed for methyl parathion of which only one analyses exceeded the RL.

Reporting Limit (RL) *refers to the concentration a laboratory has indicated their analysis method can be validated. For example, if a contaminant were at a level below the reporting limit, the laboratory's analysis method could not detect it and the concentration would be reported as "below the reporting limit".*

Throughout this report, the number of sample analyses for any one contaminant refers only to the number of analyses as reported **in the Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater**, and not for the total number of analyses for that contaminant taken in the state. As already mentioned, data which are currently in the process of being entered into the database are not reflected in this report. In addition, there are undoubtedly samples for various contaminants taken by entities other than the agencies referred to in this report (for instance, private consulting firms, or other programs within some of the reporting agencies), which are not included in this database.

Table 3 shows the number of analyses of groundwater samples for a wide variety of compounds, all of which are used in agricultural production. As mentioned previously, there is a large effort in monitoring groundwater for other, non-agricultural contaminants. Examples of such compounds include petroleum products and additives, industrial chemicals, hazardous wastes, contaminants associated with landfills and other waste disposal sites, and effluent from waste water treatment facilities. Such issues are beyond the scope of §46-1304, and information about such monitoring data is not contained in any centralized database at present.

Compound	Compound	Compound	Compound
1,1,1-trichloroethane	carbaryl	ethion	phorate
1,2,4-trichlorobenzene	carbofuran	ethoprop	picloram
1,2-dibromo-3-chloropropane	carbon tetrachloride	ethyl parathion	prometon
1,2-dibromoethane	carboxin	fenuron	prometryn
1,2-dichlorobenzene	chlordane	fluometuron	pronamide
1,2-dichloroethane	chloroform	fonofos	propachlor
1,2-dichloropropane	chlorothalonil	heptachlor	propanil
1,4-dichlorobenzene	chlorpyrifos	heptachlor epoxide	propargite
1-naphthol	cis-permethrin	hexachlorobenzene	propazine
2,4,5-T	clopyralid	hexachlorocyclopentadiene	propham
2,4,6-trichlorophenol	cyanazine	hexazinone	propoxur
2,4-D	cycloate	isofenphos	propyzamide
2,4-DB	cyprazine	isoxaflutole	silvex
2,4-dinitrophenol	DCPA	isoxaflutole benzoic acid	simazine
2,4-DP	DCPA mono and diacids	isoxaflutole diketonitrile	simetryn
2,6-diethylaniline	DDD	lindane	tebuthiuron
3-hydroxycarbofuran	DDE	linuron	terbacil
4,6-dinitro-o-cresol	DDT	malathion	terbufos
4-chloro-3-methylphenol	deethylatrazine	MCPA	terbuthylazine
4-nitrophenol	deisopropylatrazine	MCPB	terbutryn
acenaphthene	delta-HCH	methiocarb	tetrachloroethene
acetochlor	diazinon	methomyl	thiobencarb
acifluorfen	dicamba	methoxychlor	toxaphene
acrylonitrile	dichlobenil	methyl azinphos	triallate
alachlor	dichlorprop	methyl parathion	trichloroethene
aldicarb	didealkyl atrazine	methylene chloride	triclopyr
aldicarb sulfone	dieldrin	metolachlor	trifluralin
aldicarb sulfoxide	dimethenamid	metribuzin	vernolate
aldrin	dimethoate	molinate	
alpha-HCH	dinoseb	naphthalene	
ametryn	diphenamid	napropamide	
atrazine	disulfoton	neburon	
azinphos-methyl	diuron	nitrate-N	
benfluralin	endosulfan I	norflurazon	
bentazon	endosulfan II	oryzalin	
beta-HCH	endosulfan sulfate	oxamyl	
bromacil	endrin	parathion	
bromomethane	endrin aldehyde	pebulate	
bromoxynil	EPTC	pendimethalin	
butachlor	esfenvalerate	pentachlorophenol	
butylate	ethalfluralin	permethrin	

Table 3. Compounds for which groundwater samples have been analyzed. Record runs from May 1974 through mid - 2005. (Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater, 2006)

Compounds	Number of Samples Analyzed	Samples > R.L.
acetochlor	3,837	34
alachlor	16,428	523
aldrin	287	4
ametryn	2,203	1
atrazine	16,820	10,153
bromacil	270	1
butylate	13,832	6
carbon tetrachloride	230	1
chloroform	69	1
chlorpyrifos	5,856	1
cyanazine	16,439	426
deethylatrazine	12,052	9,481
deisopropylatrazine	11,937	7,172
diuron	104	1
EPTC	11,500	3
fonofos	12,822	9
isoxaflutole benzoic acid	1,034	5
isoxaflutole diketonitrile	1,034	10
methyl parathion	4,166	1
metolachlor	15,901	3,465
metribuzin	16,306	61
nitrate-N	74,525	70,023
pendimethalin	3,639	8
permethrin	2,082	5
prometon	12,282	169
prometryn	2,162	1
propachlor	11,975	56
propazine	12,174	857
simazine	12,407	459
tebuthiuron	153	2
trifluralin	15,796	32

Table 4. Compounds listed in Table 3 that were detected above the Reporting Limit.

Public Water Supplies and Nitrate

A **Public Water Supply System** routinely supplies drinking water to 25 or more people or supplies 15 or more service connections for more than sixty days each year.

Public water supply systems are required to test for a variety of contaminants potentially in the drinking water that they serve to the public. When a contaminant in the drinking water is over the federal Safe Drinking Water Act limit (also known as the maximum contaminant level [MCL]), the water system will receive an Administrative Order for that contaminant from Nebraska Health and Human Service (NHHS) and must somehow 'fix' the problem. The MCL for nitrate-nitrogen is 10 mg/l, but public water supply systems with wells or intakes testing over 5 mg/l may be required to perform quarterly sampling. Approximately 337 of the nearly 550 groundwater based community water systems in Nebraska must perform quarterly sampling for nitrates. Common methods to solve a nitrate Administrative Order include drilling a new or deeper well, hooking on to a neighboring water system, or building a treatment plant. Figure 4 below shows the 14 community public water supply systems with Administrative Orders for nitrate, as of November 2006. Please note that the public water supply system data from NHHS is not in the Database. Also note that nitrate Administrative Orders do not necessarily fall in the areas of highest nitrate problems, as indicated in Figure 5 and the figures in Appendix A.

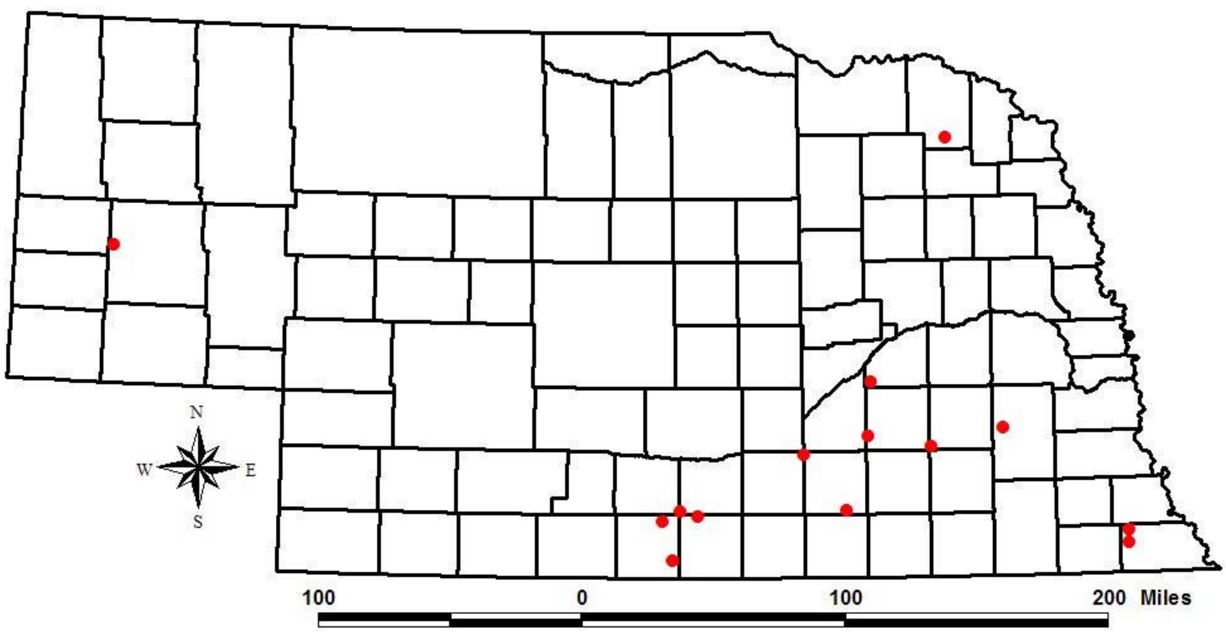


Figure 4. Fourteen groundwater based community public water supply systems on NHHS Administrative Order for nitrate above the 10 mg/l MCL. (Source: NHHS, November 2006)

Public Water Supplies and Arsenic

The agencies reporting to the Agrichemical Database do not routinely analyze groundwater for arsenic. However, arsenic is a groundwater quality concern for the state. Incidences of this naturally occurring compound are reported through the Nebraska Health and Human Services public drinking water system sampling program. The arsenic MCL changed from 0.05 mg/l to 0.01 mg/l in January 2006. This is a great concern for approximately 33 public water supply systems (21 of which are community systems), which may eventually have to build and operate treatment plants to reduce arsenic levels in their drinking water. These treatment plants will be expensive to build and operate, and will also produce a waste that will require proper disposal.

DISCUSSION AND ANALYSIS

Occurrence of elevated levels of nitrate and herbicides in groundwater has been associated with the practice of irrigated agriculture, especially corn production. A good summary of this can be found in Exner and Spalding (1990). The Natural Resources Districts have instituted Groundwater Management Areas (GWMAs) over all or parts of 20 of the 23 districts based on NDEQ and NRD groundwater sampling. The NRDs institution of these GWMAs indicates a concern and recognition of nonpoint source groundwater contamination. Additionally, NDEQ's Groundwater Management Area program (Title 196, 2002) has completed 20 studies across the state since 1988 identifying areas of nonpoint source contamination from the widespread application of commercial fertilizer.

The information presented previously in this report shows that a considerable amount of effort has gone into groundwater quality monitoring in Nebraska since the mid-1970s, especially in areas that are heavily farmed. It is worth noting that the majority of samples taken during this period show that groundwater in the State is of very high quality. An examination of Table 3 and Table 4 shows that most parameters that have been analyzed have never been detected in the samples. However, these same data show that several contaminants have been detected in numerous samples throughout the monitoring period. Levels and distribution of these compounds are issues of concern to Nebraskans.

As Table 4 shows, the compounds that have been detected more than just a few times throughout the period of record include nitrate-nitrogen, atrazine, alachlor, metolachlor, and simazine. Nitrate is a form of nitrogen common in human and animal waste, plant residue, and commercial fertilizers. Atrazine, alachlor, metolachlor, and simazine are herbicides used for weed control in a variety of crops such as corn and beans. In addition, these four herbicides have been identified as priority compounds by the Nebraska Department of Agriculture for development of pesticide State Management Plans, following guidance produced by the U.S. Environmental Protection Agency. Note that several compounds have fairly large numbers of detections but are not included as part of the priority compounds (e.g. cyanazine, propazine, desethyl atrazine and deisopropyl atrazine). Cyanazine and propazine are both triazine herbicides (like atrazine and simazine), and their use pattern is similar (the use of cyanazine has been discontinued). Desethyl atrazine and deisopropyl atrazine are degradation products, or metabolites, of atrazine, and have been detected mostly in research settings. More widespread monitoring may be necessary as further information about the toxicity of these compounds becomes available.

Nitrate

The locations of wells sampled for nitrate, as well as their measured nitrate concentrations in Nebraska are presented in Figure 4. Please note that 'empty' areas only denote areas where samples have not been taken or have not yet been reported. In other words, there is no way to tell anything about the groundwater quality in the 'empty' parts of the state. **'Empty' areas indicate no data, not a lack of nitrate in the groundwater.**

Because there would be overlapping "dots" on the map in Figure 4 if all 74,522 nitrate analyses were used, Table 5 below summarizes the information in a different way. The last column in Table 5 shows the percentage of analyses that are greater than 10 mg/l, which is the federal drinking water standard for nitrate-nitrogen.

Years	Total # Analyses	# > Lab Reporting Limit	< 7.5 mg/l	7.5 – 10 mg/l	10 – 20 mg/l	> 20 mg/l	% > 10 mg/l
1974 – 2001 (2002 Report)	33,075	30,961	21,504	2,707	5,554	3,310	26.8%
1974 – 2002 (2003 Report)	44,721	42,009	28,394	3,931	8,128	4,268	27.7%
1974 – 2003 (2004 Report)	52,798	49,265	33,100	4,606	9,857	5,027	28.2%
1974 – 2004 (2005 Report)	66,822	63,009	37,346	5,603	12,244	11,629	35.7%
1974 – 2005 (2006 Report)	74,522	70,022	42,916	6,573	13,161	11,872	34.2%

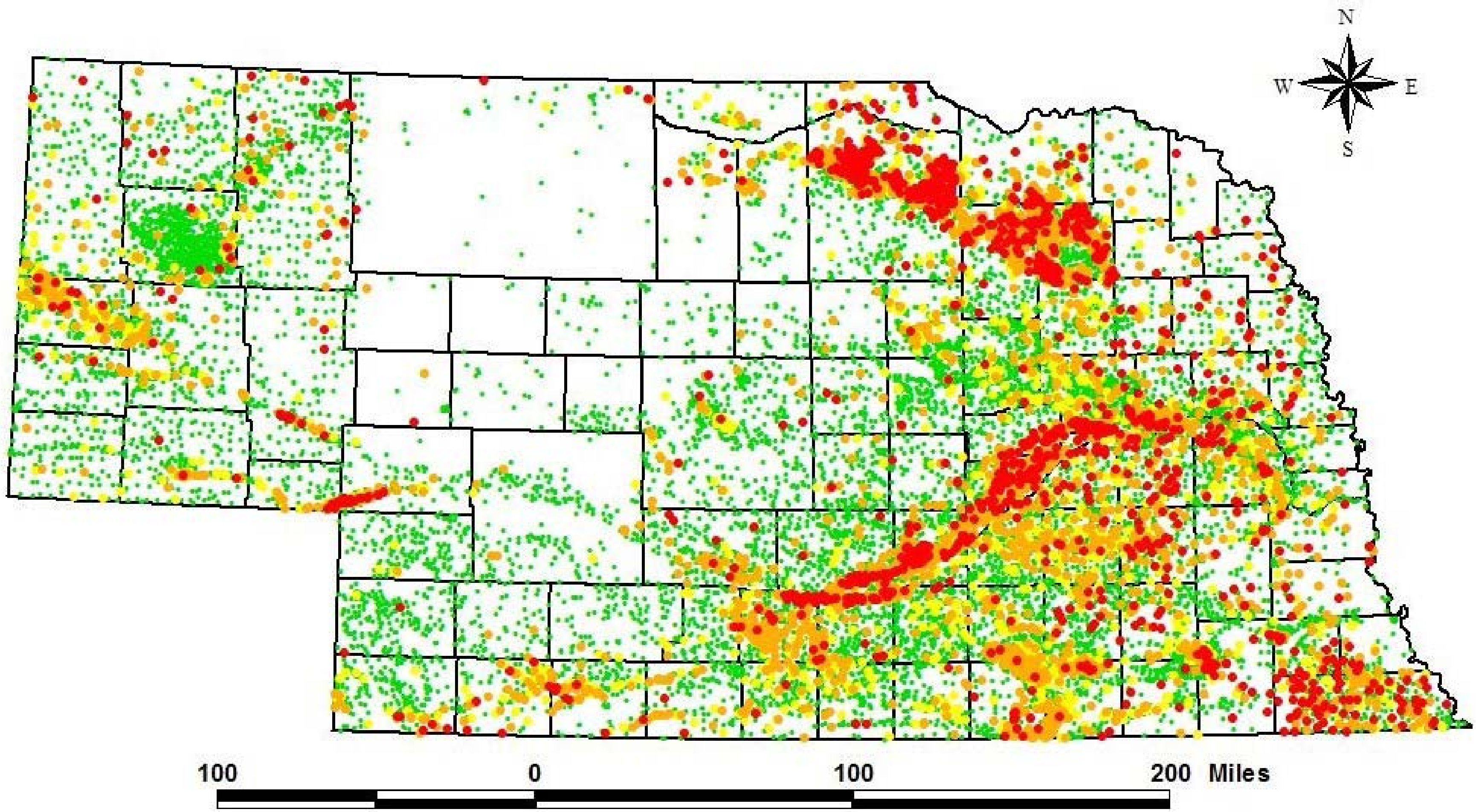
Table 5. Nitrate – nitrogen concentrations sorted by concentration categories. (Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater, 2006)

To attempt to better show the progress of the groundwater quality sampling programs in Nebraska, individual maps of annual nitrate sampling results (as reported in the Database) are shown in Appendix A, Figures A-1 through A-7. In one way, these maps give a general trend picture. However, they probably best show that making statewide trend statements is still very difficult.

These maps also show areas of the state with large concentrations of samples. Many of the individual maps in Appendix A show results of a particular study or project. For example, Figure A-2, 1982 and information from the Database indicate that the UNL-Conservation and Survey Division took approximately 400 of the 519 samples for the entire year for a particular study in southeast Nebraska. Statewide coverage becomes more consistent after the mid to late 1980s.

The State of Nebraska is a large area, over 77,000 square miles. Accurately showing the quality of Nebraska's groundwater is becoming an easier task, but this highly complex system is still difficult to characterize. The acquisition of more data is making the trend analysis more viable. However, practices of sampling the "problem" areas have skewed the data and make it very difficult to show the areas in Nebraska where the contaminant levels are decreasing through better management and farming practices.

Nitrate Concentrations



Nitrate Levels – Entire Record

- < 7.5 mg/l
- 7.5 – 10 mg/l
- 10 – 20 mg/l
- > 20 mg/l

Figure 5. Generalized nitrate-nitrogen levels in wells sampled, 1974-2005 (last recorded concentration from 21,133 wells). (Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater)

A sense of the changes in nitrate levels over time can be gained by an examination of Figure 5, Figure 6, and Appendix A figures. In general, the graph in Figure 6 shows nitrate levels between about 2 and 6 mg/l throughout most of the monitoring period, with an increase in median levels in the late 1990s. The U.S. Environmental Protection Agency's Maximum Contaminant Level for nitrate-nitrogen of 10 mg/l.

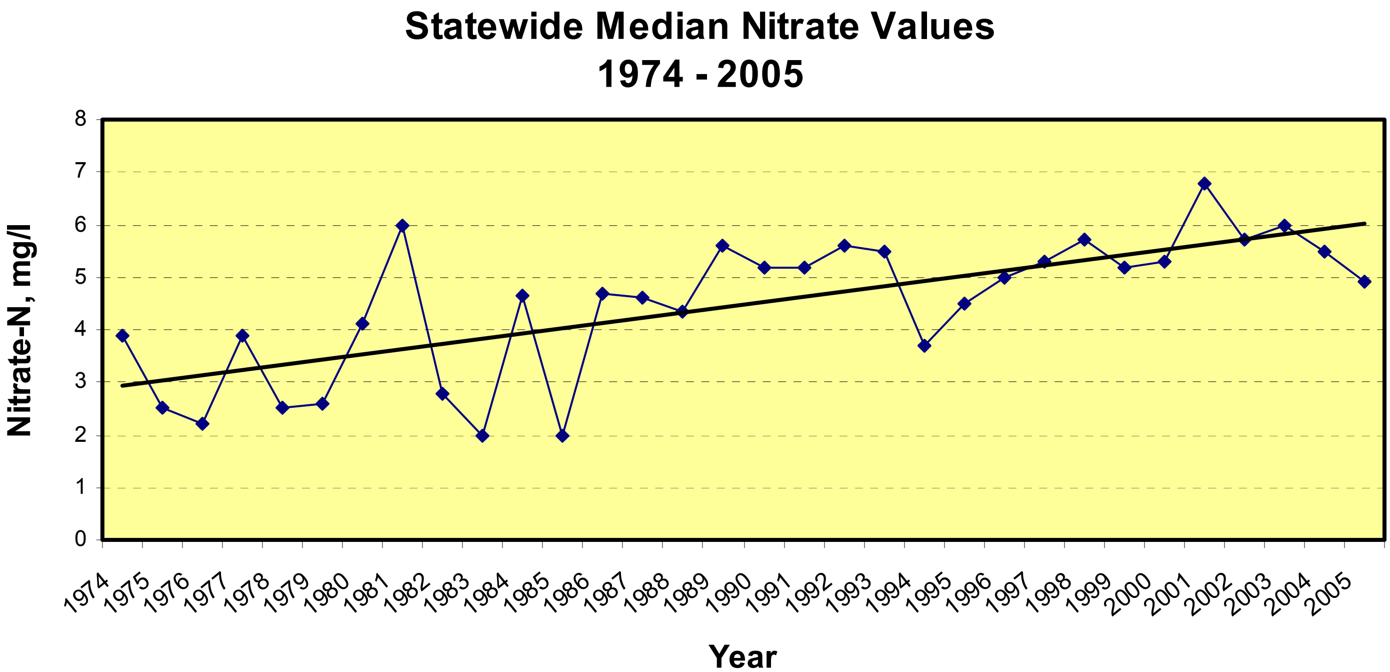


Figure 6. Median nitrate-nitrogen levels for Nebraska, 1974-2005. (Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater, 2006)

Several points are of interest when considering this graph. First, Figure 6 is a summary of **ALL** available nitrate data from the Database for the entire state for these years. No attempt has been made to separate out the specific intent of monitoring in a given year. As seen in Figure 5 and the figures in Appendix A, the data represent a mix of samples taken for regional or background studies as well as those taken to focus on areas of known concern for nitrate. Therefore, it is difficult at this point to provide information on how well the available data reflects the true overall levels of nitrate in Nebraska groundwater.

Second, note that the numbers of analyses for given years in the Database vary widely (from 2 to 5719). The bar graph (Figure 7) shows the number of analyses in the Database for that given year. At present, it is not possible to issue statements about exactly how many samples are necessary to adequately represent state nitrate levels. However, one can state that the more samples the better. Therefore, the changes in median nitrate levels from year to year as represented in Figure 6 may be as much a function of the number of samples taken in a given year as anything else. In future years, as the Database becomes more complete, these median numbers for given years may change considerably. However, it is possible to state that such data demonstrate, at many locations across Nebraska, levels of nitrate in groundwater are elevated above what would be considered a background or naturally occurring level. Such a background level is generally considered to be around 2 mg/l (R.F. Spalding, personal communication); the median levels shown by Figure 6 are typically above that level.

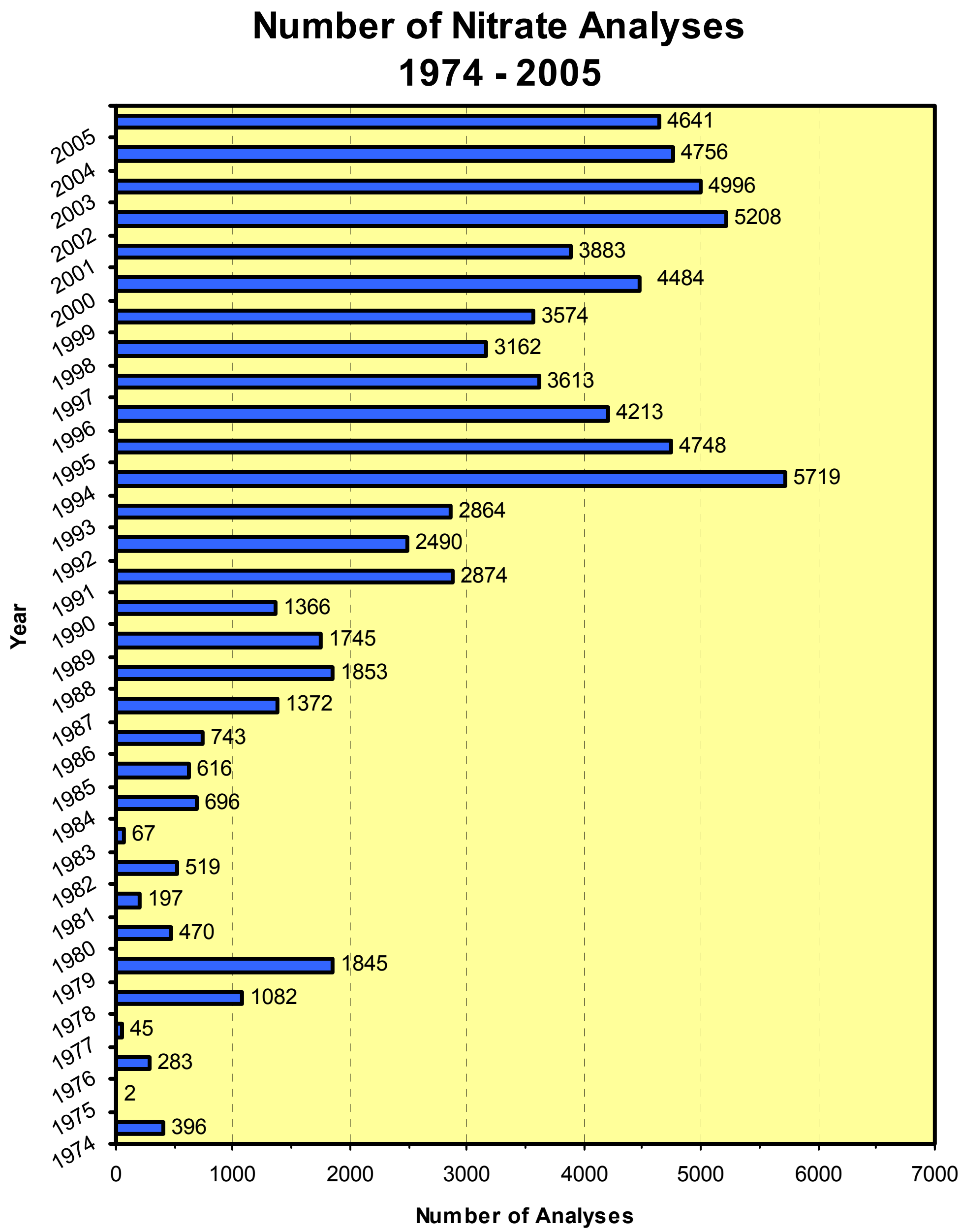


Figure 7. Number of nitrate analyses by year, 1974 – 2005. (Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater)

Third and lastly, the figures above show the considerable statewide effort put into sampling groundwater for nitrates over the past few decades. Figure 5 (and the series of maps in Appendix A) show that the greatest concentration of elevated nitrate levels occur in the central Platte

Valley and northern Holt County, although there are some higher levels in nearly all parts of Nebraska. Such vulnerable areas are typically characterized by shallow depth to groundwater, permeable soils, intense row-crop production, considerable irrigation activity, or any combination of these factors

Nitrates and Trends Utilizing the Statewide Groundwater Monitoring Network

Presenting trend analysis for the entire State of Nebraska using the Datatbase would not be representative due to the lack of data for the entire state on a year-to-year basis (see Appendix A, A-1 – A-7). Nitrate studies were completed for specific areas and were not necessarily repeated the next year in an attempt to eventually cover the entire state. Accurate trends for the state as a whole should be based on large quantities of repeated data collected over a long period of time. In response to this need, the Statewide Groundwater Monitoring Network (Figure 8) has been established by the NRDs and has completed the first years' worth of sampling. Nitrate trends from this report forward will be estimated using the information gathered from this network. The several thousand "active" wells, which have already been documented, are likely to continue to be sampled on a more-or-less regular basis by the NRDs. However, this is a large number of well locations to track on a statewide basis, thus the estimated number of network wells which will initially be used in annual analysis has been reduced to approximately 1500. Locations of 1437 network wells have been completed for the state's twenty-three NRDs. Figure 8 shows the locations of network wells in the NRDs; Table 6 shows the number and type of wells being utilized by NRD.

It is important to keep some qualifications in mind when interpreting these maps. Since each NRD has its own schedule for monitoring, individual samples may not have been taken at the same time as other samples within the same District or between Districts. Thus, at this point, each map does not necessarily represent a "snapshot" in time of nitrate levels or changes, but they do give a very general indication of how nitrate levels are changing over time. However, as time passes and the network becomes more well-established, samples will be more representative of equivalent time periods, and will be more directly comparable. It is also important to remember that aquifer systems and nitrate-nitrogen levels within them are very dynamic, complex, and variable. Although care was taken to select wells that were fairly representative of the geologic conditions present in various areas of the state, it is impossible to extrapolate conditions in a given well to a large area. Therefore, the several hundred wells in the statewide network give a general indication of how nitrate levels are changing over time across the state as a whole, but it would be inappropriate to use one or a few wells in the network to try to analyze nitrate levels in a specific part of the state.

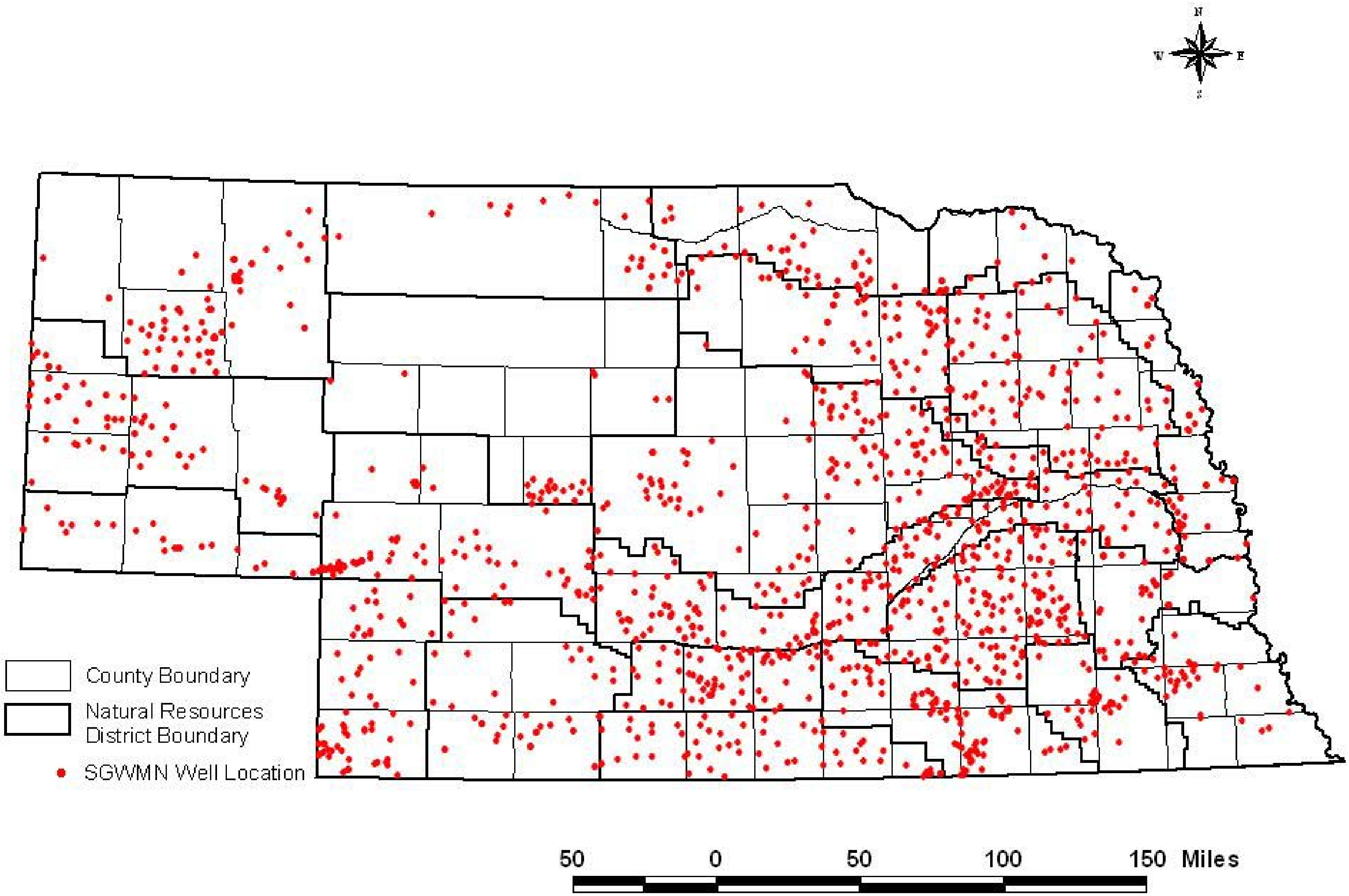


Figure 8. Statewide Groundwater Monitoring Network

Natural Resources District	Total Wells	I	Q	D	S	C
Central Platte	117	113		4		
Lewis & Clark	15	9	6			
Little Blue	83	82			1	
Lower Big Blue	30	30				
Lower Elkhorn	86	86				
Lower Loup	142	138		2	2	
Lower Niobrara	33	33				
Lower Platte North	49	49				
Lower Platte South	37	12	24			1
Lower Republican	63	54	9			
Middle Niobrara	29	10	17	1	1	
Middle Republican	46	31	15			
Nemaha	32	20		11	1	
North Platte	76	15	60	1		
Papio-Missouri River	47	19	26	2		
South Platte	25	9	16			
Tri-Basin	63	63				
Twin Platte	74	64	8	2		
Upper Big Blue	150	128	18	4		
Upper Elkhorn	66	49	17			
Upper Loup	25	23		2		
Upper Niobrara White	90	54	36			
Upper Republican	59	59				
TOTALS	**1437**	**1068**	**334**	**29**	**5**	**1**

Explanation:

I	Irrigation Well	**Q**	Monitoring Well
D	Domestic Well	**S**	Stock Well
C	Commercial Well	*	Well locations and numbers being obtained

Table 6. Well numbers, types, and totals by Natural Resources District for the Statewide Groundwater Monitoring Network.

Figures 9 and 10 and Tables 7 and 8 show the changes in nitrate-nitrogen levels in the 1437 network wells. Figures 9 and 10 show those wells where nitrate levels were increasing, decreasing, or showed no change or insufficient data. Figure 9 shows changes in nitrate levels between the last two monitoring events for each well, giving a general idea of the most recent changes in those levels. This can be considered a map of “short-term” changes in nitrate levels, in most cases showing how nitrates have changed over the last few years. Figure 10 shows changes in nitrate levels over the entire record of each well, which gives a better indication of “long-term” changes in those levels. This “long-term” change usually represents variations in nitrate levels over several years or even a few decades.

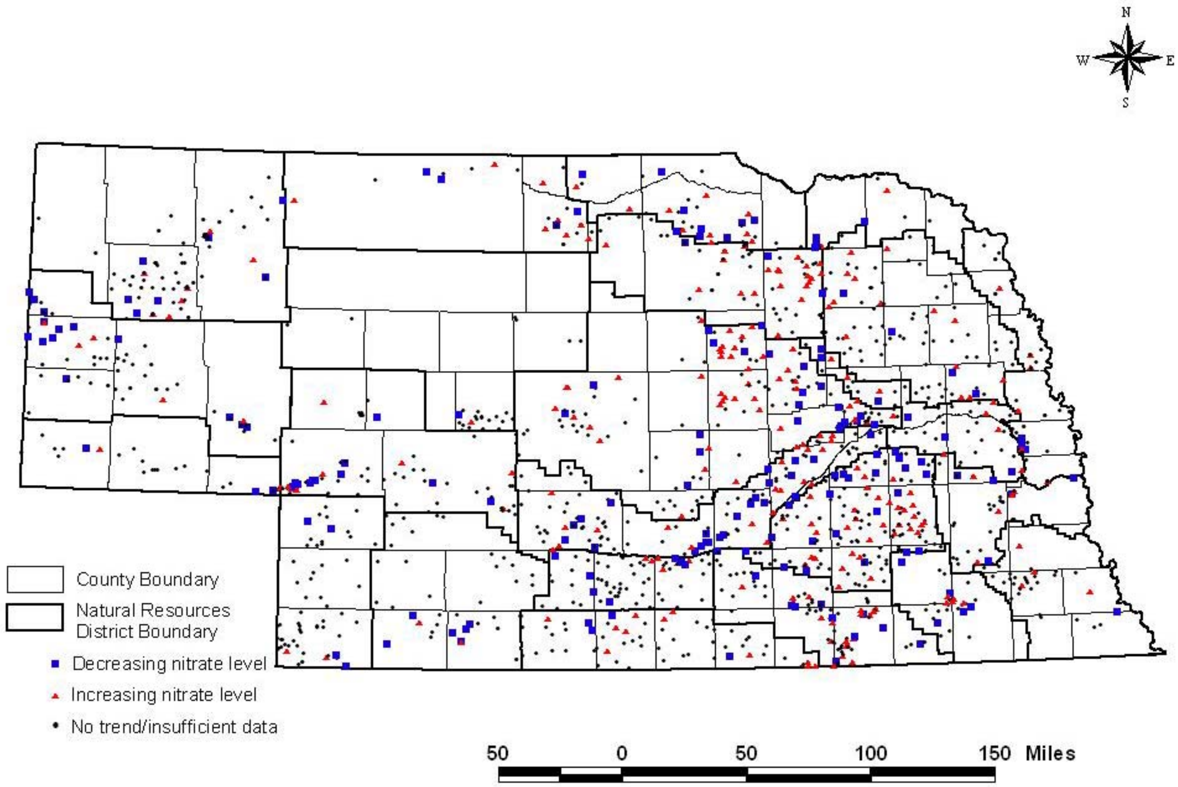


Figure 9. Change in nitrate-N levels since last monitoring event (short-term).

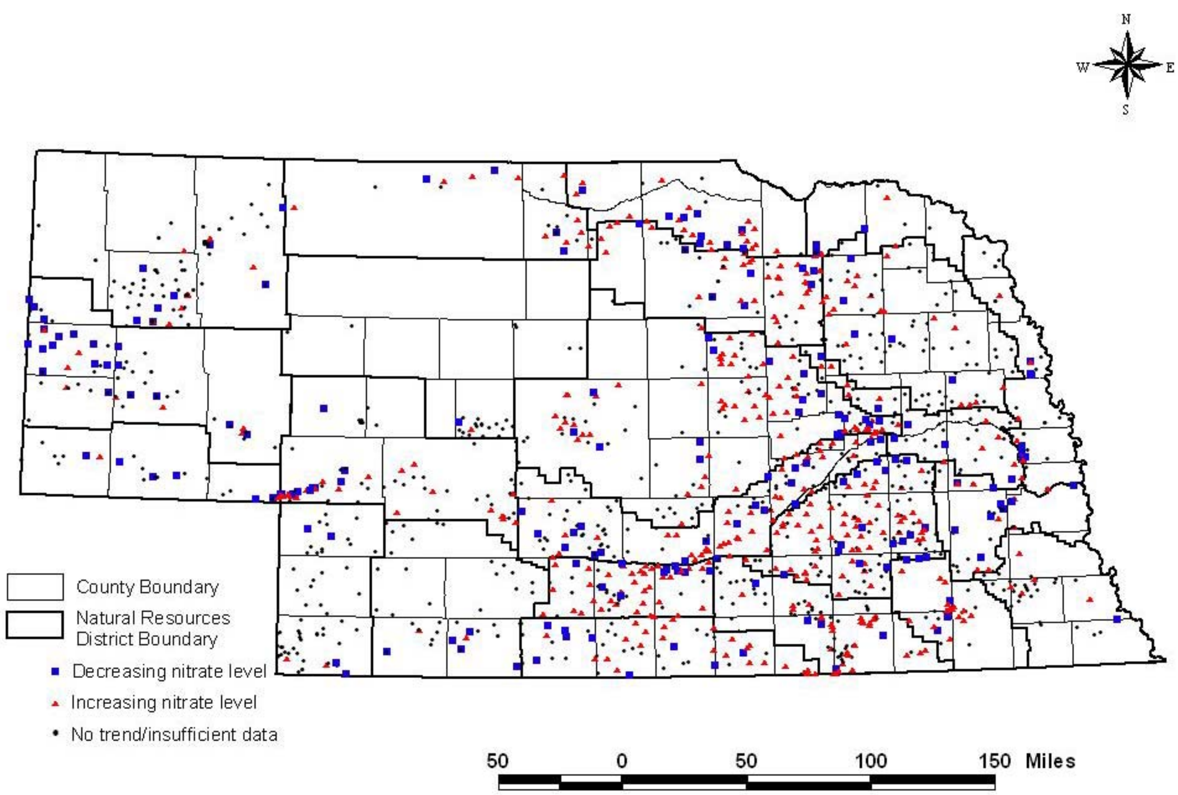


Figure 10. Change in nitrate-N levels for the entire monitoring record (long-term).

Tables 7 and 8 give a more detailed breakdown of the magnitude of the "short-term" and "long-term" changes in nitrate levels. Table 7 shows the numbers of wells for each category of increase, decrease, no change/no trend, and insufficient data for the "short-term" wells, while Table 8 shows the numbers for the same categories in the "long-term" wells.

"Short-Term" Changes in Nitrate Levels (Difference between the two most recent sampling events)	
Category	#
Total Number of Wells Showing "Short-Term" Increases	**269**
Increase >1 to 5 mg/l	221
Increase >5 to 10 mg/l	29
Increase >10 mg/l	19
Total Number of Wells Showing "Short-Term" Decreases	**187**
Decrease >1 to 5 mg/l	139
Decrease >5 to 10 mg/l	28
Decrease > 10 mg/l	20
Total Number of Wells Showing No "Short-Term" Trend	**727**
Total Number of Wells w/ Insufficient Data to Determine Trend	**254**
Total Number of Wells	**1437**

Table 7. Numbers of "short-term" wells in the Statewide Groundwater Monitoring Network showing increases, decreases, or no change in nitrate levels (this information is summarized in Figure 9).

"Long-Term" Changes in Nitrate Levels (Difference between the initial and most recent sampling events)	
Category	#
Total Number of Wells Showing "Long-Term" Increases	**458**
Increase >1 to 5 mg/l	307
Increase >5 to 10 mg/l	89
Increase >10 mg/l	62
Total Number of Wells Showing "Long-Term" Decreases	**197**
Decrease >1 to 5 mg/l	137
Decrease >5 to 10 mg/l	45
Decrease > 10 mg/l	15
Total Number of Wells Showing No "Long-Term" Trend	**528**
Total Number of Wells w Insufficient Data to Determine Trend	**254**
Total Number of Wells	**1436**

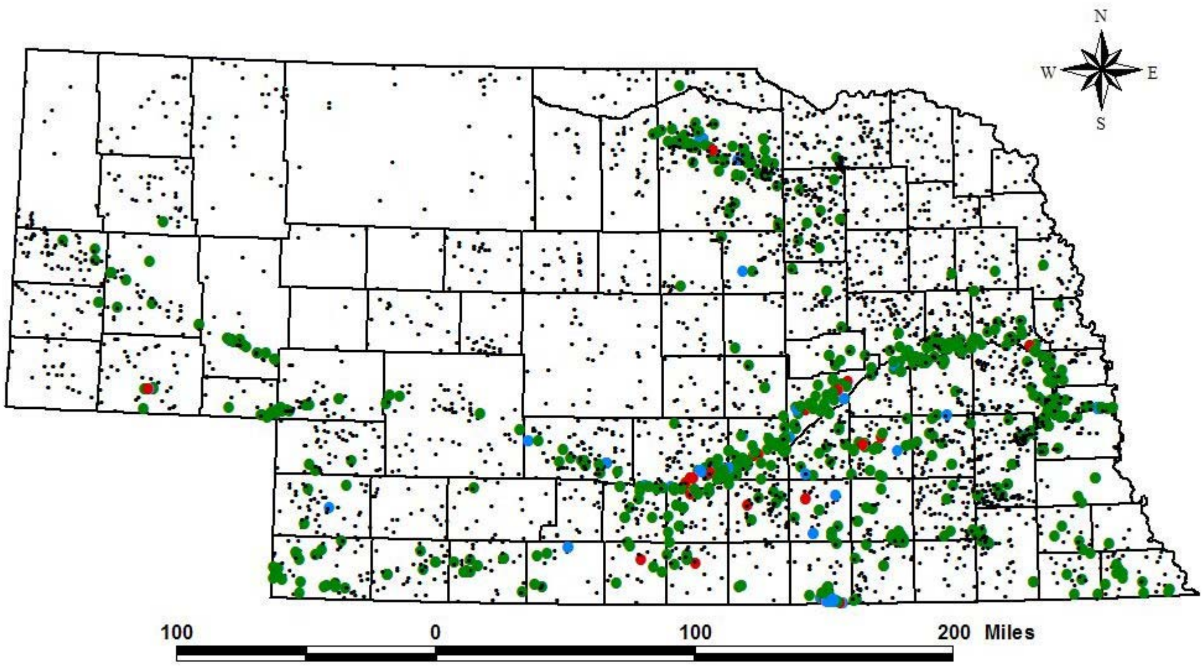
Table 8. Numbers of "long-term" wells in the Statewide Groundwater Monitoring Network showing increases, decreases, or no change in nitrate levels (this information is summarized in Figure 10).

It is important to keep some qualifications in mind when interpreting these maps. Since each NRD has its own schedule for monitoring, individual samples may not have been taken at the same time as other samples within the same District or between Districts. Thus, at this point, each map does not necessarily represent a "snapshot" in time of nitrate levels or changes, but they do give a very general indication of how nitrate levels are changing over time. However, as time passes and the network becomes more well-established, samples will be more representative of equivalent time periods, and will be more directly comparable. It is also important to remember that aquifer systems and nitrate-nitrogen levels within them are very dynamic, complex, and variable. Although care was taken to select wells that were fairly representative of the geologic conditions present in various areas of the state, it is impossible to extrapolate conditions in a given well to a large area. Therefore, the several hundred wells in the statewide network give a general indication of how nitrate levels are changing over time across the state as a whole, but it would be inappropriate to use one or a few wells in the network to try to analyze nitrate levels in a specific part of the state.

In mid-2004, the NRDs, working with NDEQ and the Nebraska Department of Agriculture (NDA), also began two new monitoring efforts. Using funding from USEPA Region 7, NDEQ and NDA placed in-house monitoring equipment for the analysis of priority herbicides (atrazine, alachlor, metolachlor, and acetochlor) in 10 of the 23 District offices, and for the analysis of coliform bacteria in 22 offices. In 2005, NDEQ obtained additional funding from USEPA to place four more herbicide units in four additional NRD offices. As of this writing, the initial monitoring seasons for these parameters have been completed and data is being analyzed. Future efforts will concentrate on evaluating these methodologies for inclusion of data in the Clearinghouse, improving quality and comparability of data, and obtaining further funding for ongoing sampling and analysis.

Atrazine

The locations of wells sampled for atrazine and the concentrations of that herbicide are presented in Figure 11. Atrazine is used as an herbicide to eradicate broad leaf weeds. Common commercial trademark names include (but are not limited to) Aatrex and Bicep.



Atrazine Detections and Levels
- ● Below Reporting Limit
- ● < 1.5 µg/l
- ● 1.5 – 3 µg/l
- ● > 3 µg/l

Figure 11. Generalized locations and levels of atrazine in wells sampled, 1974-2005 (last recorded concentration from 4,555 wells). Maximum Contaminant Level = 3 µg/l. (Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater, 2006)

The change in mean atrazine levels over time is presented in Figure 12. Again, this is a statewide mean value, giving a general sense of atrazine concentrations found in groundwater. Typically, concentrations are between 0 and 2 µg/l (compared to the U.S. Environmental Protection Agency's Maximum Contaminant Level of 3 µg/l for atrazine). The same considerations should be applied as for the nitrate levels (see above). However, since atrazine is a man-made chemical, any level of that compound in water can be stated to have occurred as a result of human activities. In the same sense as nitrate, Figures 11 and 12 demonstrate that elevated levels of atrazine exist at several locations throughout Nebraska.

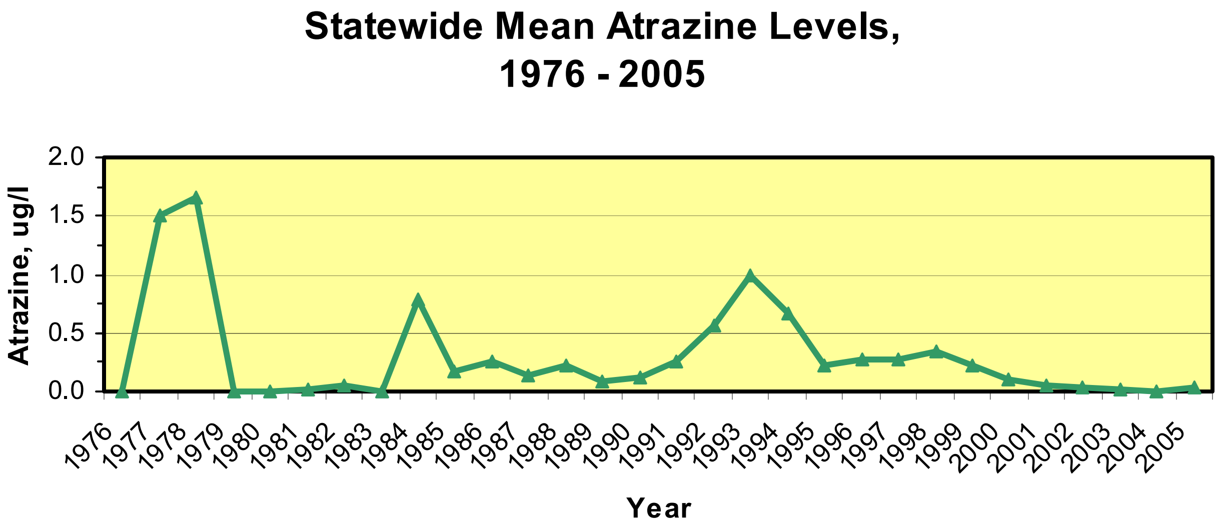
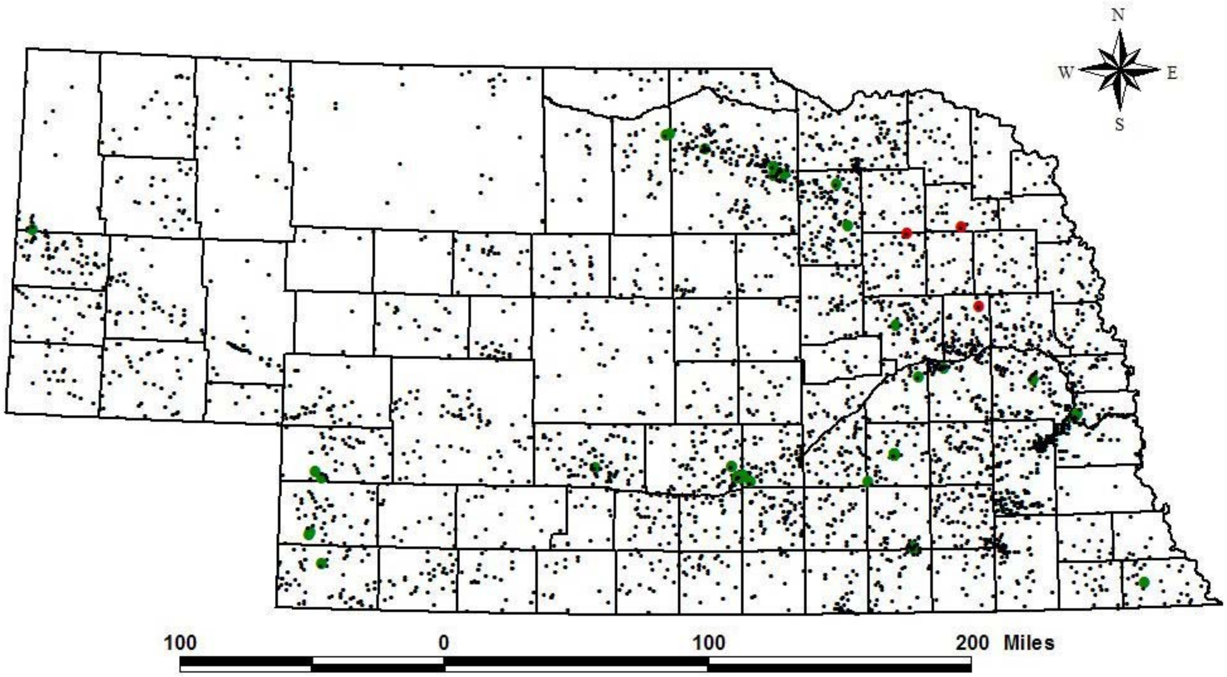


Figure 12. Mean atrazine levels for Nebraska, 1974-2005 (16,819 analyses). (Maximum Contaminant Level = 3 µg/l) (Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater, 2006)

Note that there is a difference in the statistical approach used for nitrate and atrazine as expressed in Figures 6 and 12. Figure 6 shows the **median** (central value of distribution; half the values fall above, half are below the median) value for nitrates, while Figure 12 shows the **mean** (average) value for atrazine. For large datasets, especially those that are not normally distributed, the median value represents a central tendency and is preferred over the mean since it minimizes the effect of unusually large or small values. The nitrate data in the Database meet these basic criteria and thus the median value is used. However, for the atrazine data, there are a large number of zero values, therefore the median or most commonly occurring value (mode) for most years is zero as well. For the case of atrazine, then, there is not a large variation in the values, and the mean or average value is used.

Alachlor

The locations of wells sampled for alachlor and the concentrations of that herbicide are presented in Figure 13. Alachlor is used as an herbicide to eradicate broad leaf weeds and grasses. Common commercial trademark names include (but are not limited to) Lasso, Bullet, and Lariat.



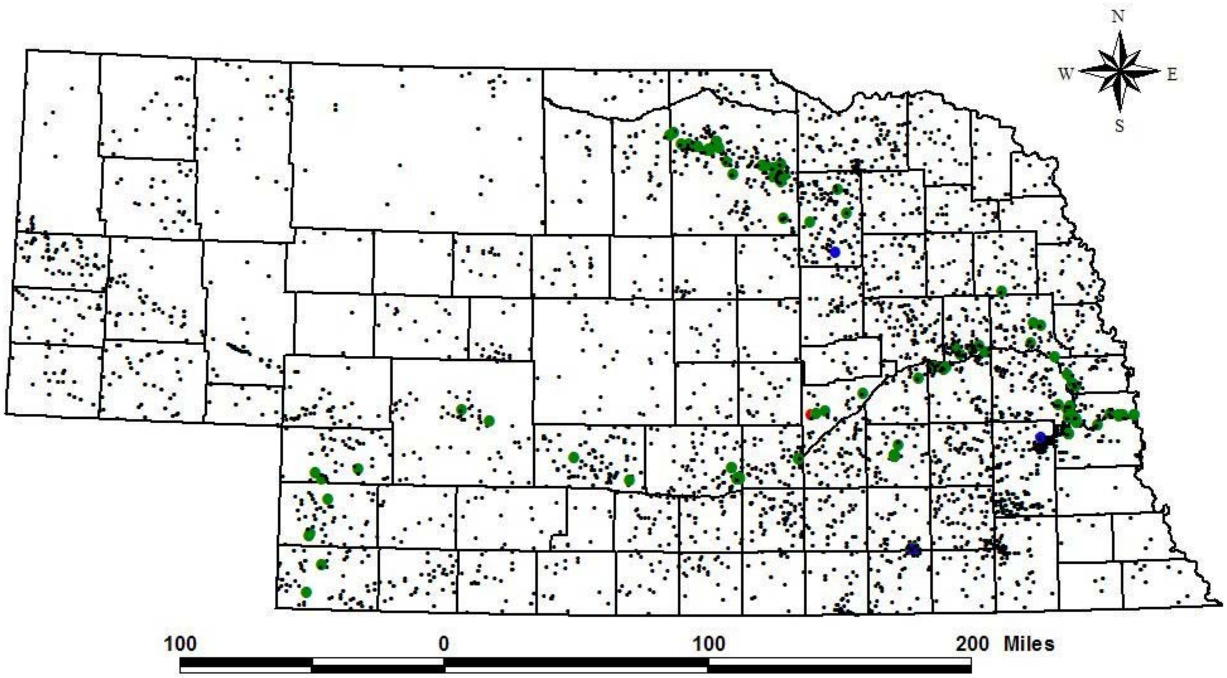
Alachlor Detections and Levels

- Below Reporting Limit
- < 2 µg/l
- > 2 µg/l

Figure 13. Generalized locations and levels of alachlor in wells sampled, 1974-2005 (last recorded concentration from 4,297 wells). Maximum Contaminant Level = 2 µg/l. (Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater, 2006)

Metolachlor

The locations of wells sampled for and the concentrations of that herbicide are presented are presented in Figure 14. Metolachlor is used as an herbicide to eradicate broad leaf weeds and grasses. Common commercial trademark names include (but are not limited to) Bicep and Dual.



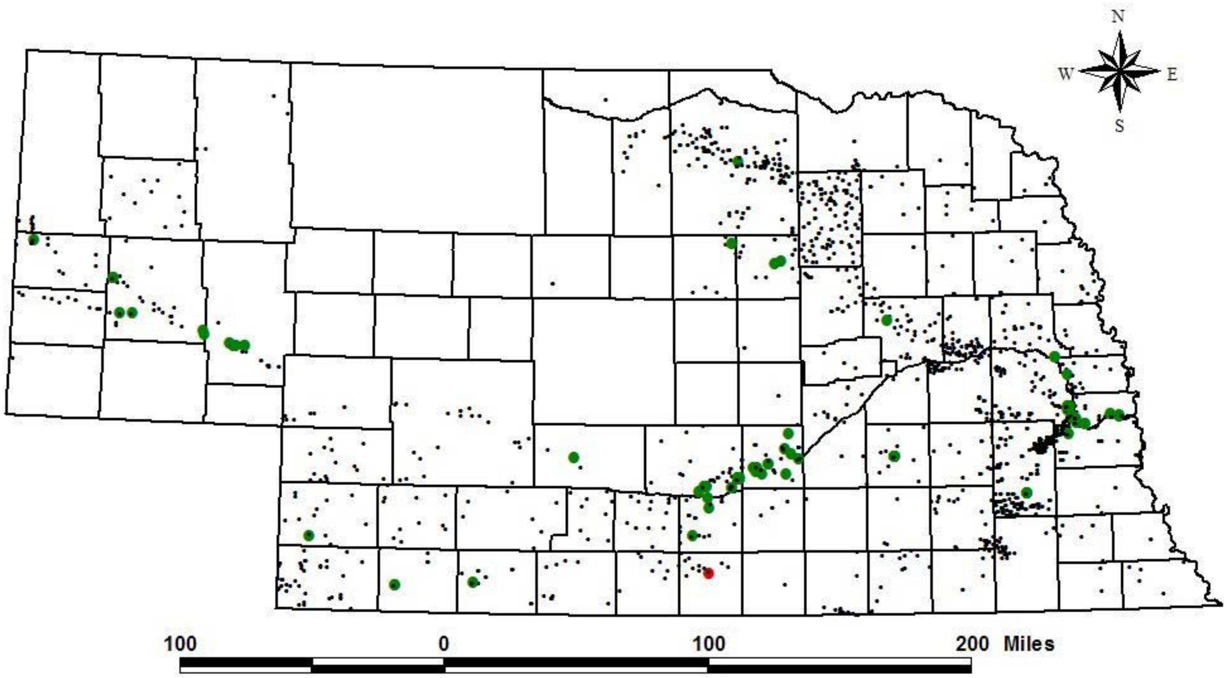
Metolachlor Detections and Levels

- ● Below Reporting Limit
- < 2 µg/l
- 2 – 4 µg/l
- > 4 µg/l

Figure 14. Generalized locations and levels of metolachlor in wells sampled, 1974-2005 (last recorded concentration from 4,115 wells). Federal Drinking Water Health Advisory = 100 µg/l. (Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater, 2006)

Simazine

The locations of wells sampled for simazine and the concentrations of that herbicide are presented in Figure 15. Simazine is used as an herbicide to eradicate broad leaf weeds. Common commercial trademark names include (but are not limited to) Princep and Aladdin.



Simazine Detections and Levels
- ● Below Reporting Limit
- ● < 1 µg/l
- ● > 1 µg/l

Figure 15. Generalized locations and levels of simazine in wells sampled, 1974-2005 (last recorded concentration from 2,178 wells). Maximum Contaminant Level = 4 µg/l. (Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater, 2006)

Pesticides and Trends

An in-depth analysis of statewide trends for any of the pesticides other than atrazine has not been attempted, because the number of detections in separate wells for these three compounds was too small to permit a reliable trend analysis. Many of the detections for these compounds were in the same wells or a series of closely spaced wells. Therefore, an analysis for trends in these parameters would not be valid. In general, the greater numbers of detections of pesticides in groundwater follows the same overall pattern of higher nitrates in groundwater. Ongoing sampling and analysis of pesticides in these areas will provide better information on the changes in levels of these compounds over time.

CONCLUSIONS

1. Nebraska's Natural Resources Districts are conducting extensive groundwater quality monitoring, focusing on nitrate and pesticides. As shown in Table 1, most of the NRDs have submitted groundwater quality monitoring data to the statewide Database. The other NRDs are submitting data through a cooperative agreement with USGS. In addition, several state and federal agencies are conducting or analyzing groundwater monitoring, resulting in a large number of analyses spread across the entire state.

2. Concentrations of contaminants such as nitrate-nitrogen and atrazine are elevated above natural or background levels. As shown in Figures 5 through 12 (and Figures A-1 through A-7 in Appendix A), nitrate and atrazine are the two most widespread contaminants detected in groundwater in Nebraska. Although nitrate is a naturally occurring compound, levels of that constituent in groundwater suggest that many areas of the state are experiencing levels above what would occur naturally. Any detections of atrazine, a man-made compound, indicate that human activity has impacted groundwater.

3. The State's 23 NRDs have instituted Groundwater Management Areas (GWMA) over 84% of the state, in the areas most vulnerable and/or impacted by nitrate contamination. NRDs with GWMAs have instituted farm operator certification, soil testing for nitrogen, irrigation water management, and other best management practices. The very slow movement of groundwater through Nebraska's soils and sediments means that decades may pass before a noticeable decline of nitrate concentrations is realized.

4. Implementation of the Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater has been invaluable in the preparation of this report and should be continued. Use of the Database has made it possible to quickly and confidently retrieve groundwater quality data for the entire state. This report authorized by Neb. Rev. Stat. § 46-1304 (LB 329, 2001) would be extremely difficult, if not impossible, to prepare were it not for the existence of the Database. The Database should continue to be implemented for the foreseeable future.

5. Implementation of the Statewide Monitoring Network will reflect a better picture of Nebraska's Groundwater. The Statewide Groundwater Monitoring Network is in its first year of sampling. Because of varying approaches used by the 23 Natural Resources Districts, the first few years' worth of data from the Network will allow only a very general analysis of short- and long-term nitrate trends. As time passes, this data will become more uniform and allow more detailed analysis.

6. Groundwater is one of the most valuable resources for Nebraska. Nebraska's residents rely on groundwater for drinking water, agriculture, and industry. This reliance makes it important to continue to monitor groundwater quality and to coordinate and share monitoring techniques, to enable decision makers to make more informed management decisions. Continued identification of a set of wells that are sampled on an on-going basis (Statewide Monitoring Network) and coordination of monitoring activities will continue to help manage and protect groundwater.

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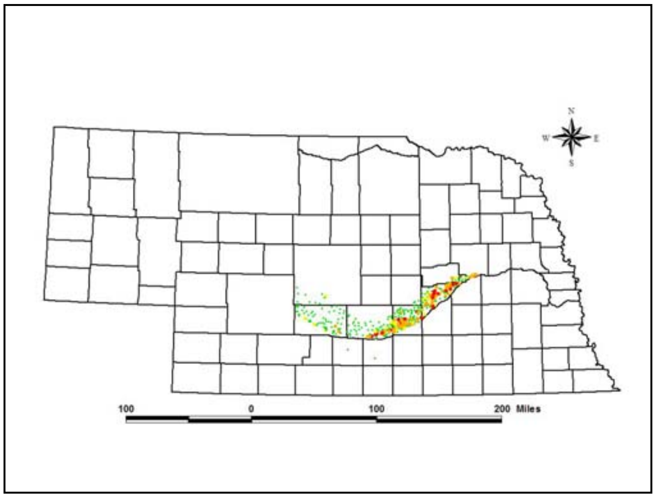
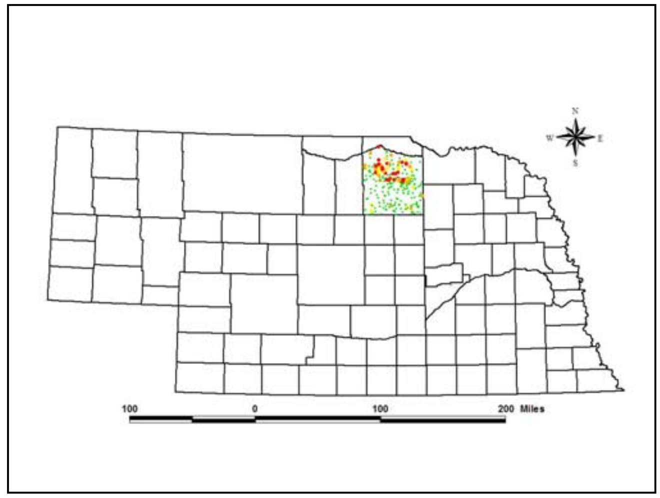
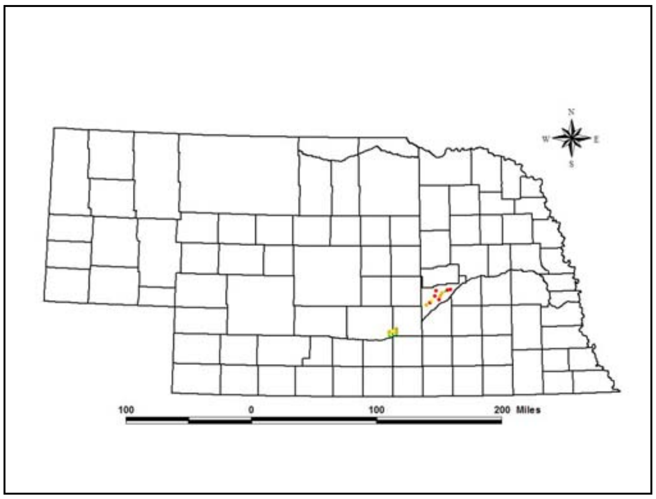


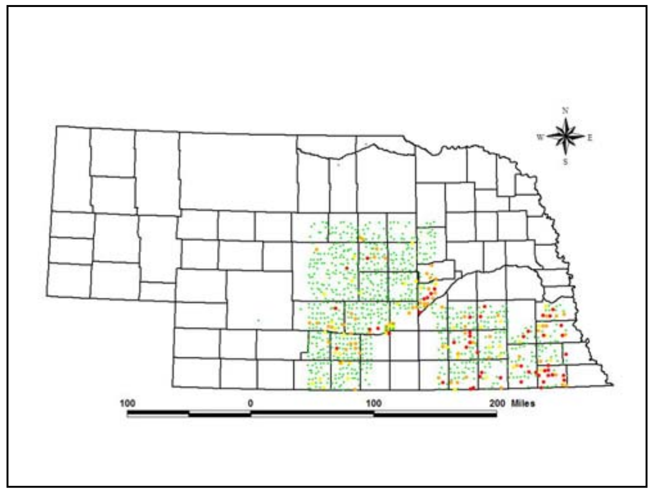
1974 - 1975 (1974 = 396, 1975 = 2 analyses)



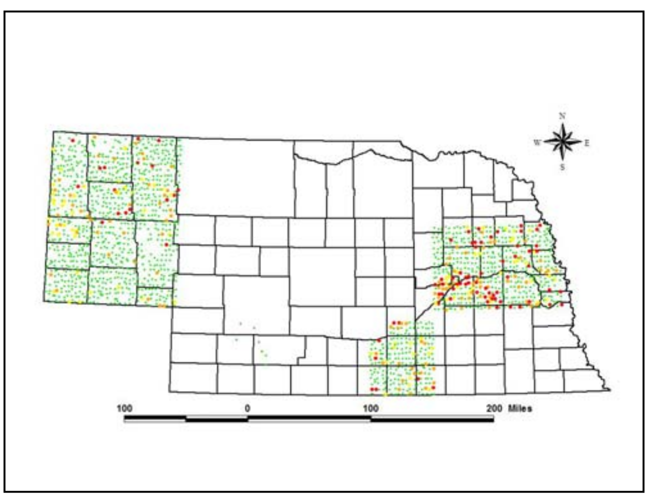
1976 (283 analyses)



1977 (45 analyses)



1978 (1082 analyses)



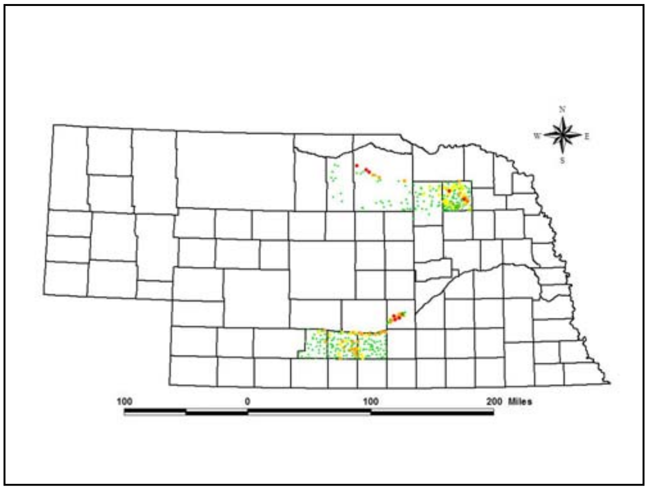
1979 (1845 analyses)

Figure A-1. Nitrate analyses for years 1974 – 1979. (Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater)

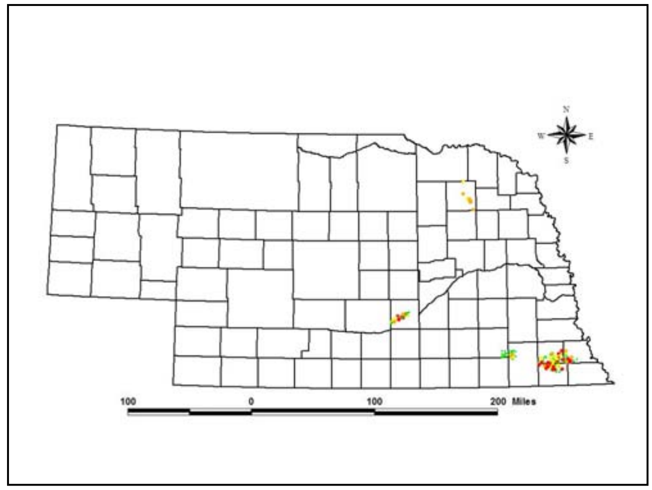
Nitrate Levels

- < 7.5 mg/l
- 7.5 – 10 mg/l
- 10 – 20 mg/l
- > 20 mg/l

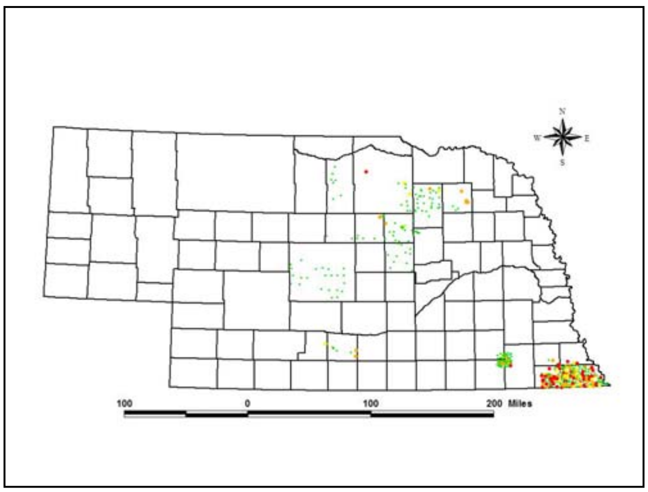
Empty areas indicate no data reported. These maps were provided to give you a snapshot of the data. To see them better, view the report on NDEQ's web site (www.deq.state.ne.us) and use your Adobe Acrobat reader to enlarge individual maps.



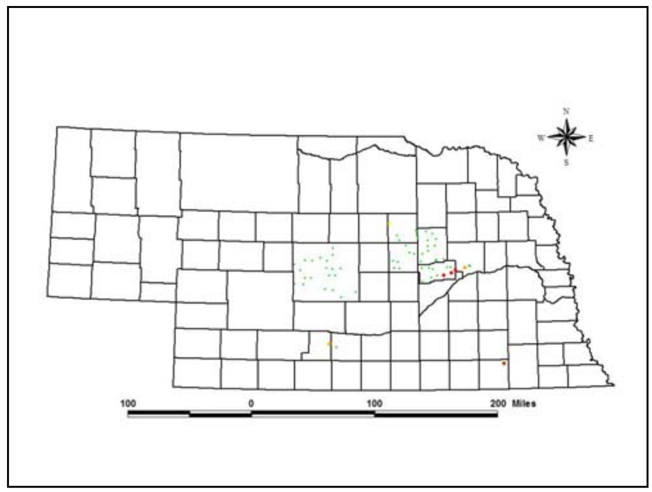
1980 (470 analyses)



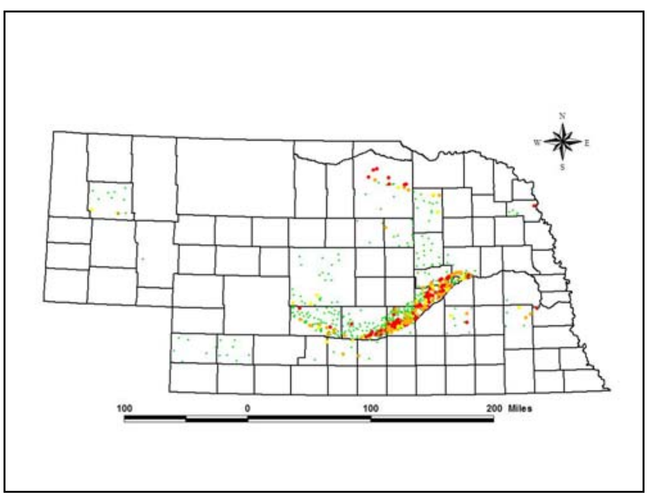
1981 (197 analyses)



1982 (519 analyses)



1983 (67 analyses)



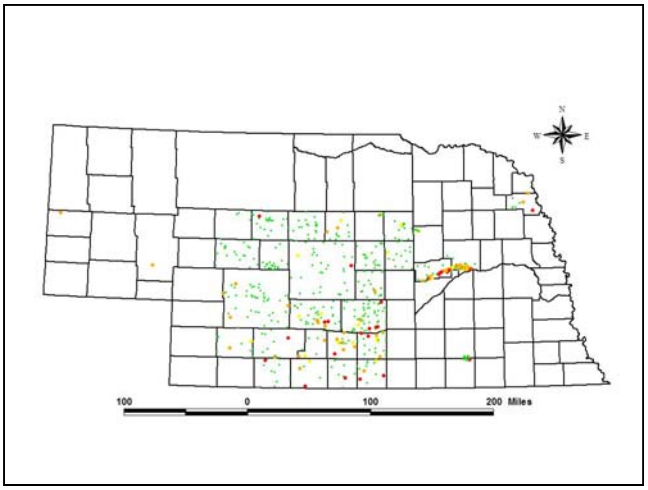
1984 (696 analyses)

Figure A-2. Nitrate analyses for years 1980 – 1984. (Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater)

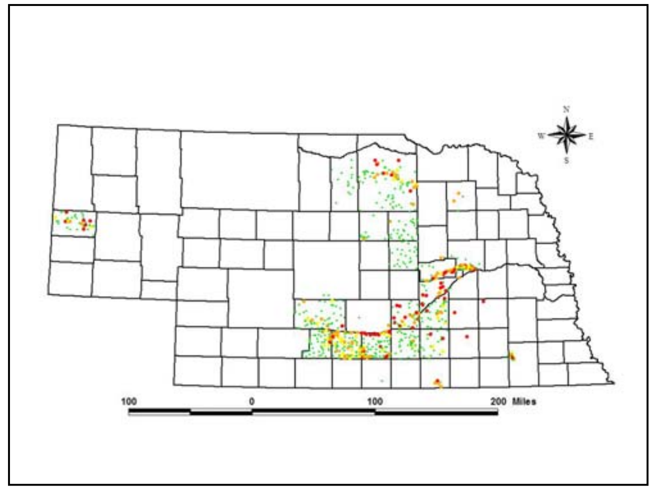
Nitrate Levels

- < 7.5 mg/l
- 7.5 – 10 mg/l
- 10 – 20 mg/l
- > 20 mg/l

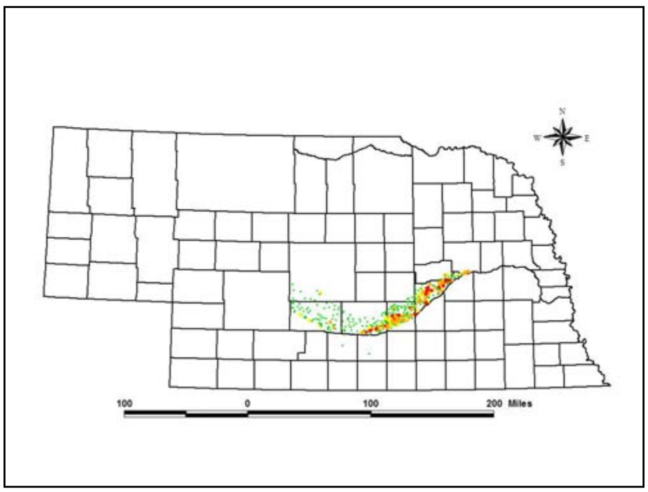
Empty areas indicate no data reported. These maps were provided to give you a snapshot of the data. To see them better, view the report on NDEQ's web site (www.deq.state.ne.us) and use your Adobe Acrobat reader to enlarge individual maps.



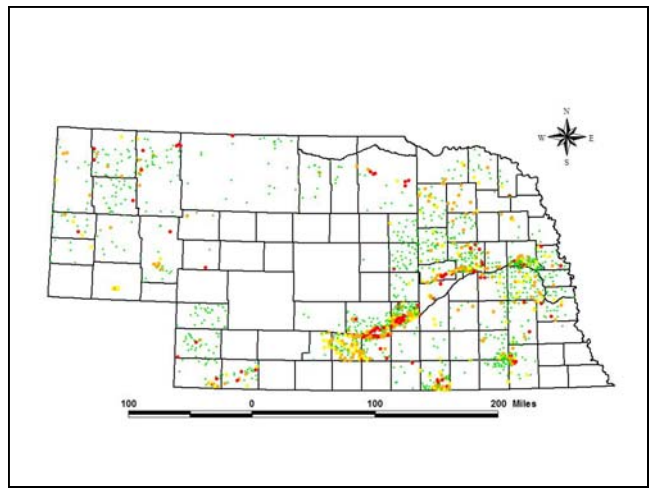
1985 (616 analyses)



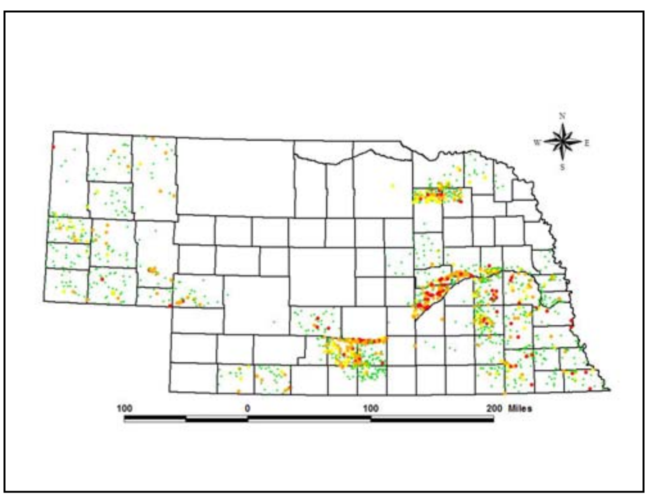
1986 (743 analyses)



1987 (1372 analyses)



1988 (1853 analyses)



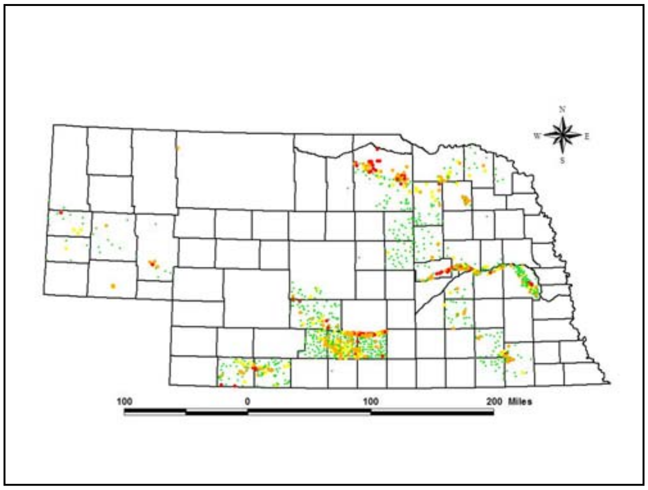
1989 (1745 analyses)

Figure A-3. Nitrate analyses for years 1985 – 1989. (Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater)

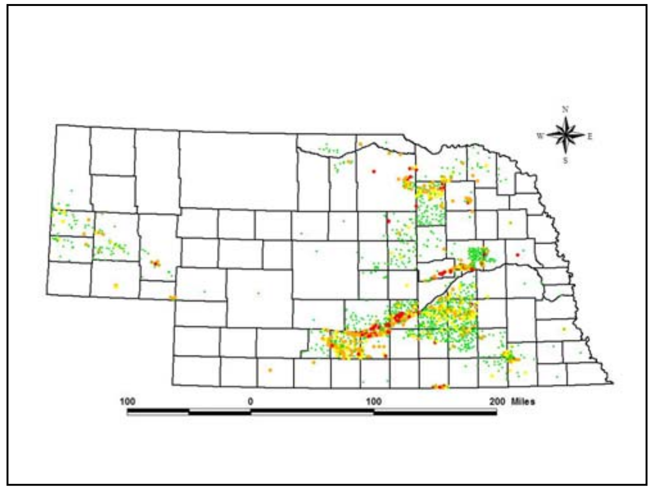
Nitrate Levels

- < 7.5 mg/l
- 7.5 – 10 mg/l
- 10 – 20 mg/l
- > 20 mg/l

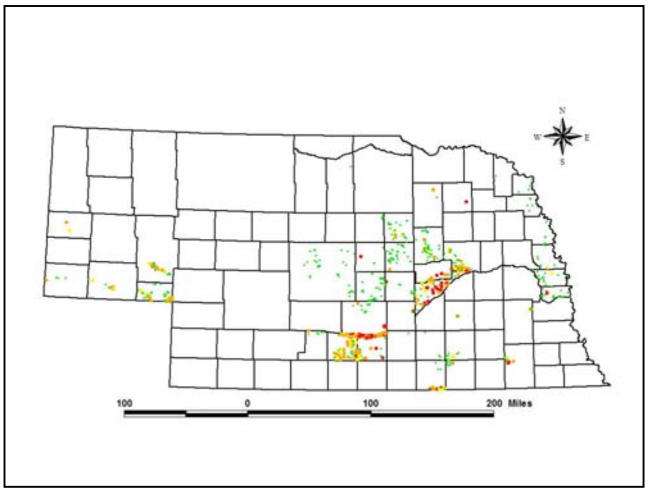
Empty areas indicate no data reported. These maps were provided to give you a snapshot of the data. To see them better, view the report on NDEQ's web site (www.deq.state.ne.us) and use your Adobe Acrobat reader to enlarge individual maps.



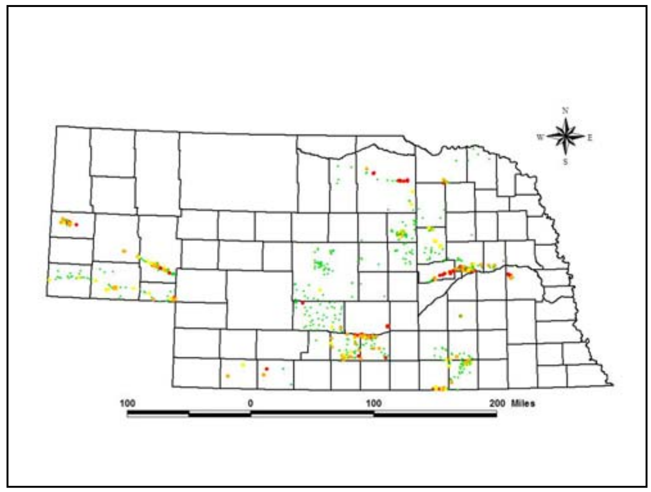
1990 (1366 analyses)



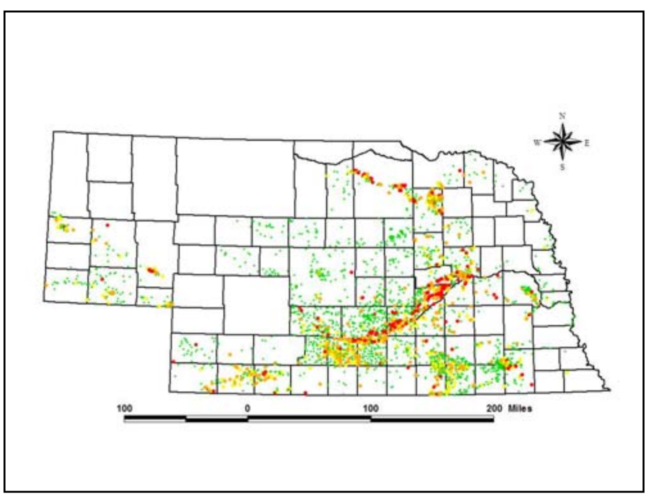
1991 (2874 analyses)



1992 (2490 analyses)



1993 (2864 analyses)



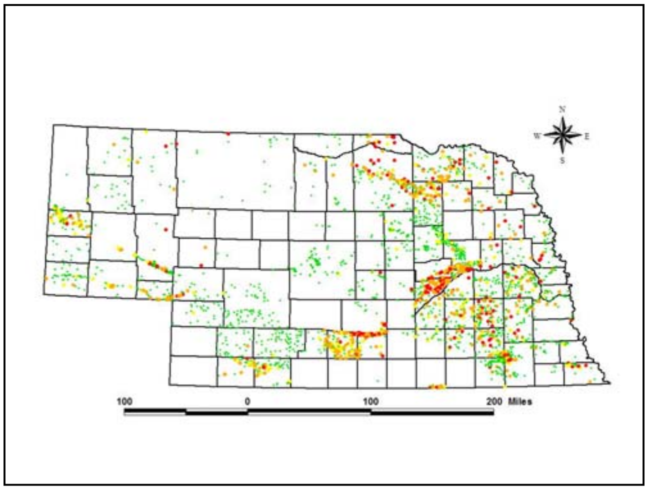
1994 (5719 analyses)

Figure A-4. Nitrate analyses for years 1990 – 1994. (Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater)

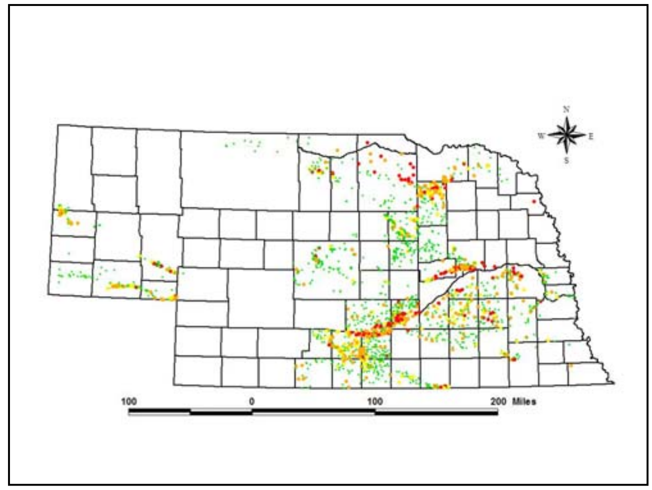
Nitrate Levels

- < 7.5 mg/l
- 7.5 – 10 mg/l
- 10 – 20 mg/l
- > 20 mg/l

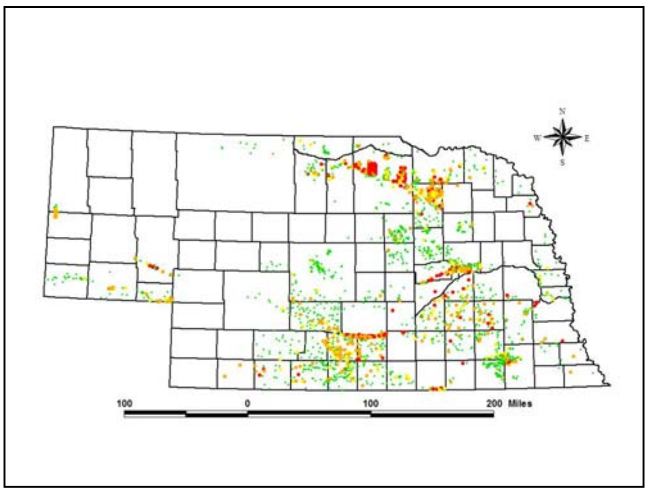
Empty areas indicate no data reported. These maps were provided to give you a snapshot of the data. To see them better, view the report on NDEQ's web site (www.deq.state.ne.us) and use your Adobe Acrobat reader to enlarge individual maps.



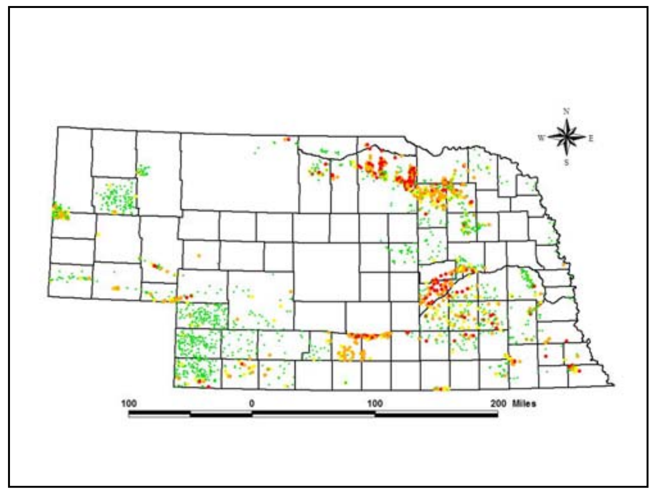
1995 (4748 analyses)



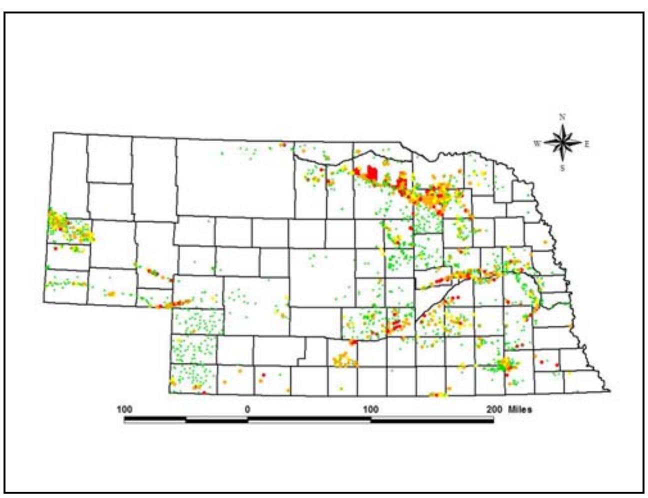
1996 (4213 analyses)



1997 (3613 analyses)



1998 (3162 analyses)



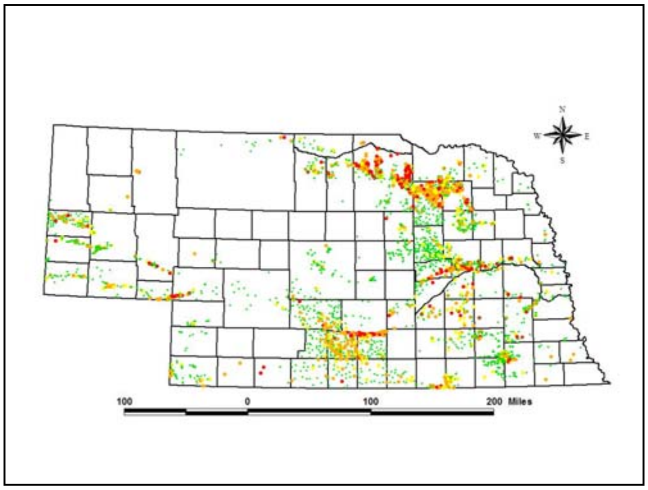
1999 (3574 analyses)

Figure A-5. Nitrate analyses for years 1995 – 1999. (Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater)

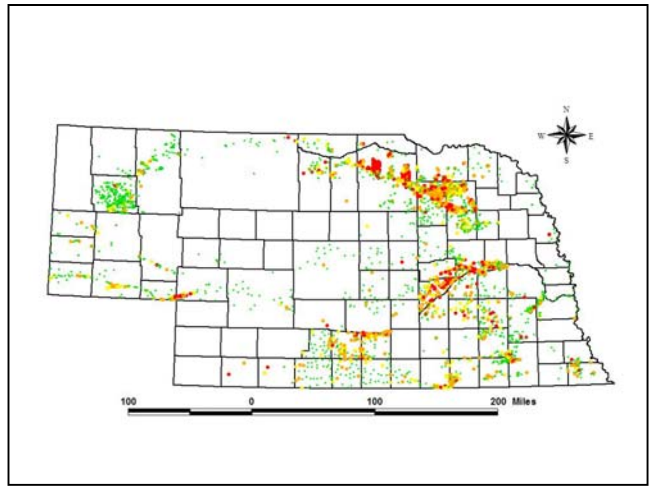
Nitrate Levels

- < 7.5 mg/l
- 7.5 – 10 mg/l
- 10 – 20 mg/l
- > 20 mg/l

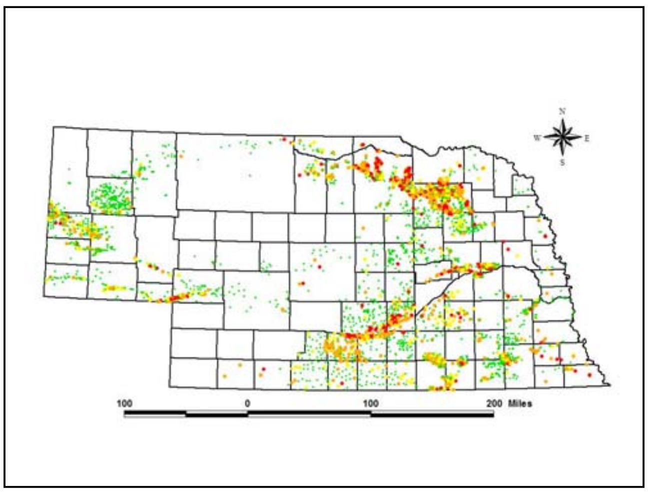
Empty areas indicate no data reported. These maps were provided to give you a snapshot of the data. To see them better, view the report on NDEQ's web site (www.deq.state.ne.us) and use your Adobe Acrobat reader to enlarge individual maps.



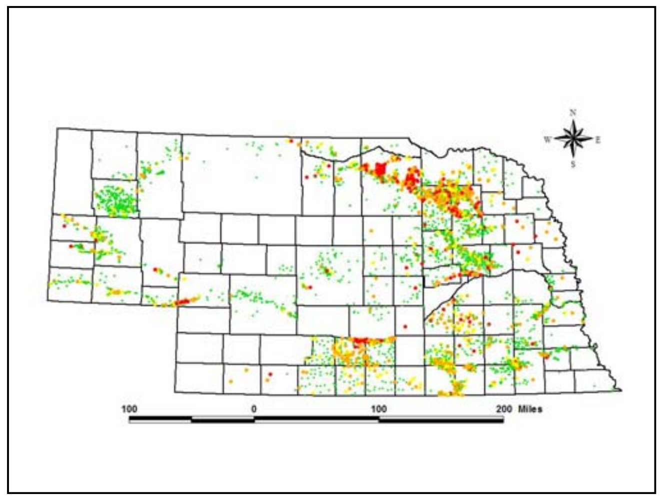
2000 (4484 analyses)



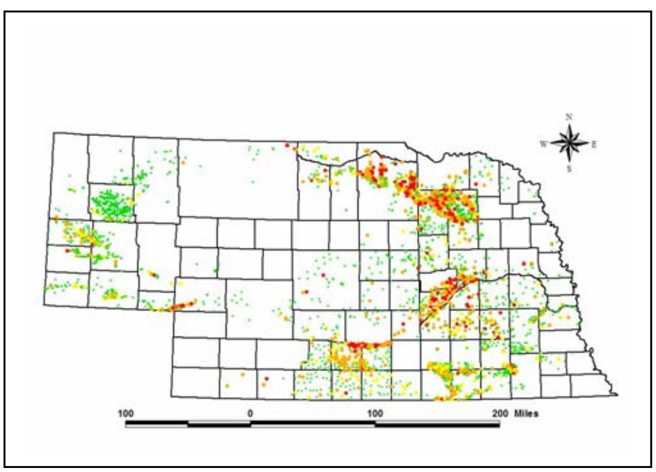
2001 (3883 analyses)



2002 (5208 analyses)



2003 (5996 analyses)



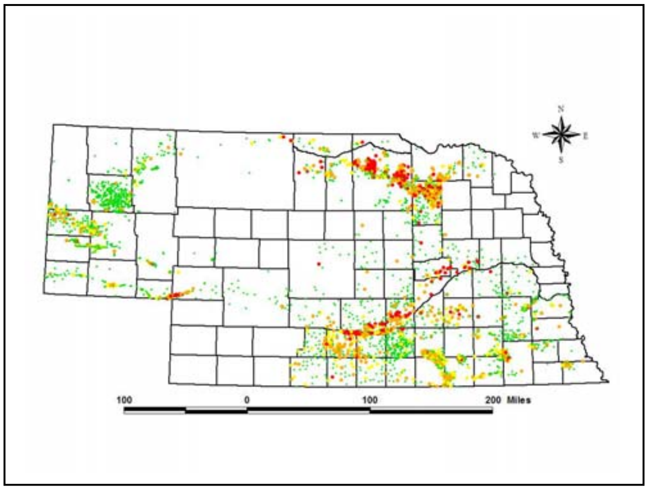
2004 (4756 analyses)

Figure A-6. Nitrate analyses for years 2000 – 2004. (Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater)

Nitrate Levels

- < 7.5 mg/l
- 7.5 – 10 mg/l
- 10 – 20 mg/l
- > 20 mg/l

Empty areas indicate no data reported. These maps were provided to give you a snapshot of the data. To see them better, view the report on NDEQ's web site (www.deq.state.ne.us) and use your Adobe Acrobat reader to enlarge individual maps.



2005 (4641 analyses)

Figure A-6. Nitrate analyses for years 2000 – 2004. (Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater)

Nitrate Levels

- < 7.5 mg/l
- 7.5 – 10 mg/l
- 10 – 20 mg/l
- > 20 mg/l

Empty areas indicate no data reported. These maps were provided to give you a snapshot of the data. To see them better, view the report on NDEQ's web site (www.deq.state.ne.us) and use your Adobe Acrobat reader to enlarge individual maps.